ECOLOGICAL STUDIES OF TWO HERBACEOUS SPECIES AROUND ORAI (JALAUN) IN BUNDELKHAND REGION

Thesis Submitted

TO

THE BUNDELKHAND UNIVERSITY, JHANSI

For The Degree

OF

Doctor of Philosophy

IN

BOTANY

By

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D. V. POSTGRADUATE COLLEGE

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2004

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DECLARATION

I herey declare that the thesis entitled ***"Ecological studies of two herbaceous species around Orai (Jalaun) in Bundelkhand region"*** being submitted to Bundelkhand University, Jhansi for the Degree of Doctor of Philosophy in Botany is an Original piece of research work done by me and to the best of my knowledge and belief the thesis or any part of the thesis has not been published in any other university or examining body in India or abroad earlier.

Date : 22.11.2004

(Neel Ratan)

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CERTIFICATE

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This is to certify that the thesis entitled ***"Ecological studies of two herbaceous species around Orai (Jalaun) in Bundelkhand region"*** is an original piece of research work done by Neel Ratan, M.Sc. (Botany) under my guidance and supervision for the degree of DOCTOR OF PHILOSOPHY in Botany of Bundelkhand University, Jhansi (U.P.) India. I further certify that :

i) the thesis has been duly completed,

ii) it embodies the work of the candidate himself,

iii) the candidate has worked under me for more than 24 months at the Institute from the date of registration.

iv) the thesis fulfils the requirements of the ordinance relating to the Ph.D. degree of the University, and

v) it is up to the standard both in respect to the contents and literary presentation for being referred to examiners.

Date : 22.11.2004

(R.K. Gupta)
Guide/Supervisor

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2. Studies on dry forage production and quality of *Iseilema* grassland community as influenced by legume introduction in Bundelkhand region (U.P.). *Advancing Frontiors of Ecological Researches in India*, Sagar (in press).

3. Primary productivity and system transfer functions in *Dichanthium* grass stands of Bundelkhand region (U.P.). *Journal of Current Bio-Sciences*, Bhavnagar, (in press).

4. Species composition, plant biomass, primary productivity and system transfer functions in a *Heteropogon* grassland of Bundelkhand region (U.P.). *Plant and Nature*, Kanpur (in press).

5. Production ecology of a warm tropical monsoonic deciduous forest at Dang's in Gujrat, India. *Journal of Biological researches*, Kanpur (in press).

6. Grazing studies to determine carrying capacity of *Bothriochloa* grassland community in Bundelkhand region (U.P.). *Range Management and Agroforesty*, IGFRI, Jhansi (Communicated).

7. Biomass dynamics, species diversity, net production and turnover rate in a grassland community in Bundelkhand region (U.P.). *International Journal of Ecology and Environmental Sciences*, New Delhi (Communicated).

8. Net Primary production relations in Shisham *(Dalbergia sissoo* Roxb.) plantation in Orai Forest Division, Bundelkhand region (U.P.). *Indian Journal of Forestry,* F.R.I. Dehradun (Communicated).

9. Education, training and awareness in environment science for rural development in Bundelkhand region (U.P.). *Flora and Funa,* Jhansi (communicated)

CHAPTER - I

GENERAL INTRODUCTION

GENERAL INTRODUCTION

An individual is the product of its heredity and environment. The former is decided at the stage of zygote itself while the latter controls optimal expression at different ontogenetic stages of growth and development, concentrating chiefly on the role of environment. Clements (1920) wrote, "Every Plant" is a measure of the conditions under which it grows. To this extent, it is a measure of soil and climate, "Besides, he developed a detailed appreciation of plants as indicators of the environmental variable after applying the principles of plant physiology for the purpose. Thus species with specific genotype may have variations under different sets of environmental complex. Turesson (1922) pioneered the studies on this aspect and stressed the importance of different environmental races of the same species differing with respect to variations of temperature, light and soil etc. He noted that some of these phenotypes may have better adoptabilities and have a higher survival value over their parents. Workers like Dobzhansky (1970), Sanaydon (1973) and Harper (1977), have supported these observations. Harper (1982) stresses, plants of a single species, sampled from a wide range of habitats and grown together in an experimental garden, differ often profoundly in features of growth-form and life cycle". Thus it is widely agreed that physiological

studies of environmental modifications are made relevant as they are frequently adaptive. Heslop Harrison (1964), has reported that these all are of much evolutionary significance and can also be utilized in comparing the taxa on behavioural attributes as suggested by Davis and Heywood (1963) in their recent approach to taxonomy (Experimental Taxonomy).

Harper *et al.* (1961) provided an insight into the taxonomic relationship on the one hand, and useful informations are derived on their ecophysiological adaptations on the other hand. They are of much agronomic value when applied on the crop plants. In such studies, one or more of these environmental variables are, at one time experimentally allowed to vary while others are kept constant and the behaviour of plants in terms of various growth attributes are judged. These investigations, conducted in controlled or semi-controlled environments can aim at complete descriptions of physiological responses in relation to the specific edapho-climatic conditions prevailing in the region. It also contributes to our understanding of magnitude of adaptive changes required for a species to broaden its tolerance under different habits. Therefore, an understanding of the physiological behaviour of plants under different ecological perspectives, is needed to enhance the agricultural productions which constitute the main sources of food for human being and domesticated animals. In the background of the

above noted facts the two species of *Alysicarpus*, namely *A.monilifer* DC. and *A.rugosus* DC. have been taken for investigating their comparative performance under different conditions of light intensities, soil moisture stress, varying sowing dates and competition after growing them in the semi control environments. The species of *Alysicarpus* are perennial herbs, distributed throughout the tropics of the old world and naturalised. All the species are good as nutritive fodder. In India *A.monilifer* is used as a common fodder. *A.rugosus* is also an excellent fodder and is often sold in the market. It requires soil of medium to high fertility and is resistant to soil alkalinity. It is fed to cattle after chopping in admixture with bhusa or other dry fodder.

In view of these specialities it was considered worth while to compare the performance of *A.monilifer* and *A.rugosus*, under varying soil moisture, varying sowing dates and competition with respect to well established parameters of growth including dry matter and leaf area, relative growth rate, net assimilation rate, leaf area ratio, specific leaf area, leaf weight ratio and shoot/root ratio. Scores were also made on germination to understand the critical conditions of establishments which provide a suitable initial condition for the introduction, survival and maintenance as component of the community of which they form a part. They are autogamous plants and hence, show genetic purity of the stock.

Some pertinent reasons for selecting these plants as experimental materials were (1) These species are very commonly grown throughout India including the edapho-climatic conditions for this region, (2) Reports on the comparative biology of these plants in which the growth attributes like RGR, NAR, LAR, SLA, LWR and S/R ratio have been compared are scanty, (3) Data on comparative performance of two closely allied species are recently being sought for wide group of taxa is considered much useful towards achieving a "general purpose" classification (Davis and Heywood, 1963). This classification can be used not only by taxonomists but also by ecologists, physiologists, geneticists and biochemists (Snaydon, 1973). Blackman (1919) and Briggs *et al.* (1920) were the pioneers to start the concept of growth analysis for measuring the behaviour of plants under different environmental conditions. Workers including Heath and Gregory (1933), Williams (1946), Watson (1947), Blackman and Black (1959), Coonise (1960), Hughes and Evans (1962), Whitehead and Myercough (1962), Myercough and Whitehead (1967), Wilson (1981), Fisher and Edwards (1982) have contributed much towards the understanding and elaboration of growth analysis technique on various plants. In India, Asana (1950) applied the concept on sugarcane crop. Since then several workers also have contributed towards the understanding of growth and productive bahaviour of various crops under different stresses of

abiotic and biotic factors (Chency and Nanda, 1951; Miśra, 1956; Sinha, 1965; Ramkrishan and Kumar, 1971; Marwah and Ambasht, 1972; Pandey, 1976; Dua and Sharma, 1977; Singh *et al.*, 1981; Goel, 1983; Kumar, 1986; Lallan, 1988 etc.

In this context, it is worth noting that several reports (Teidjens, 1928; Danielson, 1944; Fukushima *et al.*, 1968; Matsumato *et al.*, 1981; Chung *et al.*, 1982; Bengtsoson and Jensen, 1983) are there in which the effects of various factors on some of the yield components and certain agronomic characters have been dealt with on these two forage legumes. However, no significant information, particularly from this agroclimatic condition, is available, in which the analysis of growth have been made under the influence of varying environmental conditions noted above. As such, the present work has been undertaken for estimating their range of tolerance and adaptability.

The present study deals with the "Ecological studies of two herbaceous species around Orai (Jalaun) in Bundelkhand region." The thesis has been divided in nine chapters. Each chapter has been divided in introduction, materials and methods, results and discussion. Chapter I deals with General Introduction. Chapter II gives an account of site description, climate and soil. Chapter III describes the biodata, phytogeography and economic importance of *Alysicarpus*. This is followed by Chapter IV giving an account of

seed germination. Chapter V throws light on biomass, productivity and energy dynamics. Chapter VI deals with effect of shading on growth. Chapter VII gives an account of effect of soil moisture on growth. Chapter VIII describes the intraspecific competition. This is followed by Chapter IX containing summary. The thesis ends with a list of references.

CHAPTER - II

SITE DESCRIPTION, CLIMATE AND SOIL

THE STUDY AREA

Location and Topography

The present study deals with the ***"Ecological studies of two herbaceous species around Orai (Jalaun) in Bundelkhand region".*** The above study is confined to a grassland comminity situated in the premises of Bohadpura Sheep Farm, Orai at lat. $25^0 59'$ N, long $79^0 37'$ E, and is about 141.61 meters above mean sea level in northern part of the Bundelkhand region. The study site is at a distance of about five km towards north west of Orai, District Jalaun, U.P. (Fig. 2.1).

Bundelkhand is suitable for good growth of grasses and has a central position in the country. The site for investigation is a part of land bounded by Yamuna river in north, Betwa river in south and Madhya Pradesh State in the West.

Two species of *Alysicarpus* i.e. *A. monilifer* DC.(Plate-I) and *A. rugosus* DC.(Plate-II) were selected for present study because these two species were common in the grasslands of Orai (Jàlaun).

Besides southern marginal area, the topography of this region is of undulating type. Trans-Yamuna plain is another name of Bundelkhand plain, which is topographically divisible into three east-west running belts i.e. Southern, Northern and Central belts.

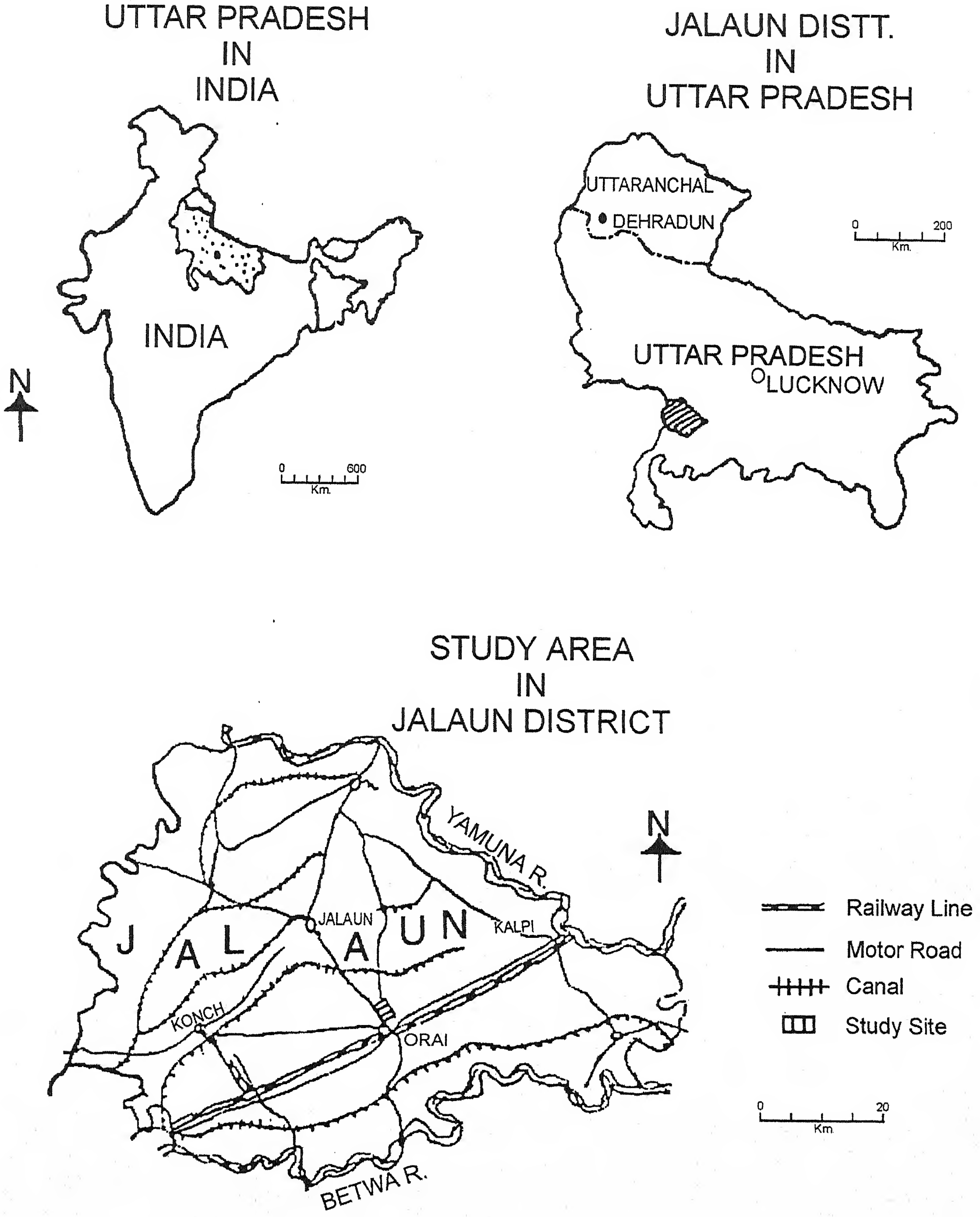

Fig.2.1: Map showing the location of study site.

PLATE - I : Showing *Alysicarpus monilifer.*

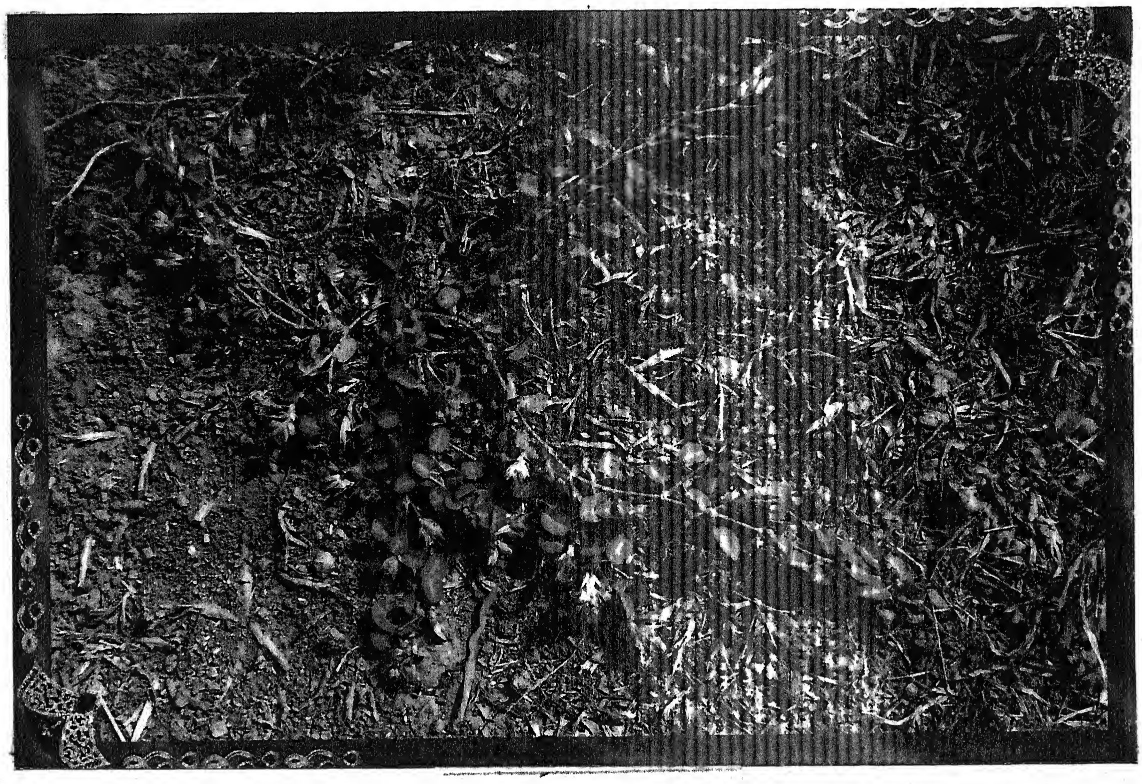

PLATE - I

PLATE - II : Showing *Alysicarpus rugosus.*

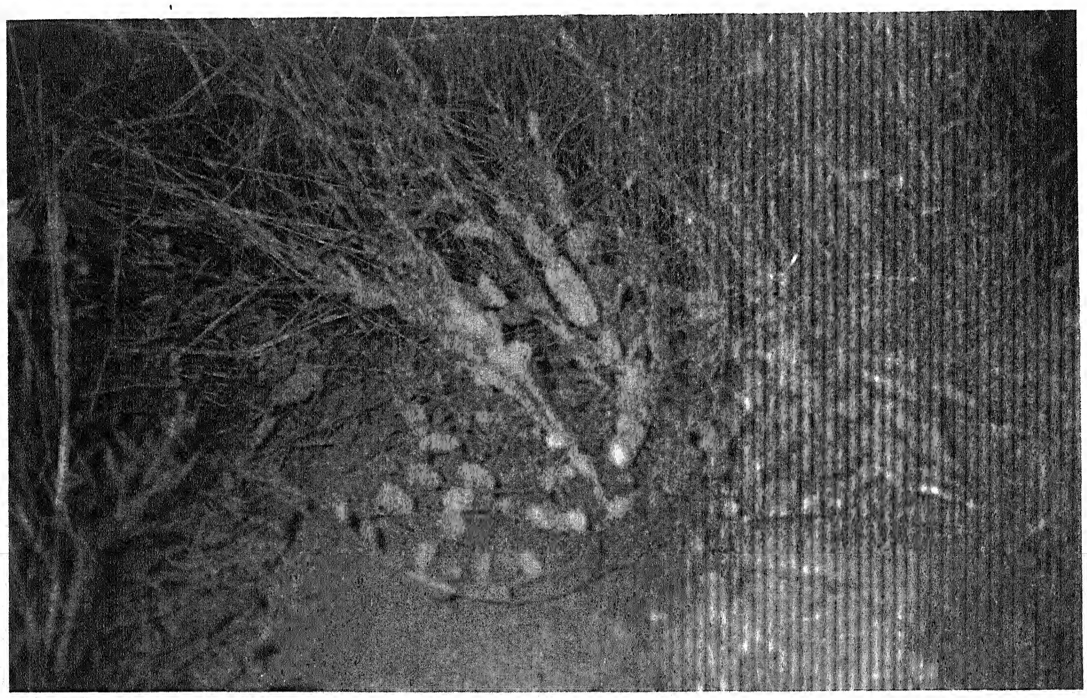

PLATE - II

Orai is located in Northern belt and confined along the bank of the river Yamuna in the form of high ground which represents the level of ancient flood plain but at present is badly cut into ravines.

Lithology

Sand stones. lime stones and shales are the common rocks. The special features of immense geographical interest in this region are quartz. reefs and dolarite dykes which are long and narrow with serrated ridges. The geological system is covered in the north west and north east by Ganga-Yamuna alluvial deposits in the form of an 'embayment'.

Natural Vegetation

The region is ecologically degraded and the original vegetation has almost been removed for inhabitation and cultivation. Shrubs and grasses represent the secondary growth throughout the region. Babul is the principal type of *Acacia*. Khair is the common tree but not much utilized. Hingota. Karondha and Kareel are mostly utilized for grazing.

Alibizzia procera (Siris). *Anogeissus pendula* (Dhawana), *Tectona grandis* (Teak). *Butea monosperma* (Dhak). *Salmalia malabarica* (Semal). *Boswellia serrata* (Salai), *Dalbergia sissoo* (Shisham), *Acacia catechu* (Khair), *A. nelotica* (Babool). *Zizyphus mausitian* (Bair). *Carissa carandus* (Karondha), *Capparis*

aphylla (kareel), *Balanites aegyptica* (Hingota), *Albizzia lebbek* (Black Siris) are the main contributors in the natural vegetation of this region.

Climate

The climate of Bundelkhand Region is typically dry sub-humid and has a distinct seasonality. It is characterised by three seasons.

(i) Rainy season : (July to October) It is warm and wet.

(ii) Winter season : (November to February) It is cool and dry.

(iii) Summer season : (March to June) It is hot and dry.

The climatic records of Orai are summarized in Table 2.1 and depicted in Fig. 2.2A.

The summer season is dry and hot with scorching sun and strong westerly winds during the days. Maximum temperature rises up to 41.02^{0}c. The amount of rainfall in summer is usually low i.e. 229.3 mm accounting for about 24.34% of the total annual precipitation. The relative humidity in summer ranged between 25.3 to 66.6%.

The summer is followed by the warm and humid rainy season of about 4 months (i.e. July-October). Monsoon brings rain by the end of the June. The rainy season receives most of the

Table 2.1: Climatic records at Orai (2002-2003)

Months	Temperature			% Relative humidity			Wind velocity km/hr			Rainfall monthly (mm)	Solar radiation K cal/m²x 10^3
	Mean max.	Mean min.	Mean month	Mean morn.	Mean even.	Mean month	Mean morn.	Mean even.	Mean month		
July	34.82	22.93	28.87	69.16	64.71	66.59	3.55	4.55	4.00	371.20	67.83
August	36.16	22.90	29.06	62.48	58.03	60.25	4.13	4.38	4.25	136.40	52.70
September	37.30	21.78	29.50	53.90	35.40	44.65	1.73	3.13	2.43	115.20	52.20
October	34.94	18.31	26.62	49.70	39.58	44.64	2.00	2.48	2.24	10.40	64.63
November	30.96	16.70	23.83	57.13	50.13	53.63	1.66	2.46	2.06	62.10	50.40
December	25.27	8.51	16.89	54.70	50.20	52.45	1.74	2.45	2.09	11.80	48.20
January	22.50	6.07	14.28	54.30	40.90	47.60	2.38	2.32	2.35	5.30	53.78
February	26.24	7.36	16.80	49.90	34.80	42.35	1.80	3.33	2.56	-	59.64
March	33.20	13.27	23.23	44.70	43.00	43.85	2.58	3.35	2.96	1.80	67.89
April	40.99	21.30	31.14	39.50	31.10	35.30	2.60	4.37	3.48	-	76.80
May	41.02	25.86	33.44	22.10	22.90	27.50	3.45	5.74	4.59	33.00	82.46
June	39.86	24.55	32.20	61.56	52.33	56.94	2.33	3.46	2.89	194.50	75.90

rainfall (about 67.2% of the annual) resulting into a fall of atmospheric temperature to an average of 28.52^{0}c. This is the season of maximum growth of the plant and biological activities. The average relative humidity during the season ranged between a minimum of 44.46% to a maximum of 66.95%.

The rainy season is followed by the winter season extending from November to February. The temperature begins to fall from early November and the coldest months are December and January. Days are sunny, bright and cool and nights are quite cold with minimum temperature going occasionally down to 6.07^{0}c. The ground surface gets some moisture by dew formation early in the morning. The season is relatively dry with occasional sporadic showers in the month of January. Precipitation in winter is about 79.2mm i.e. nearly 8.41% of the total annual rainfall and the average relative humidity ranged between 42.35 to 53.63%. The total annual precipitation (i.e. from July, 2002 to June, 2003) was 941.7mm.

Gaussen (1960) has shown the effectiveness of the climatic factors like rainfall, monthly temperature and dry period during a year by means of Ombrothermic diagram. The same is depicted in Fig. 2.2B for the better understanding of the climatic factors. It is evident from this that an average, 8 month (i.e. November-June) were xeric during the study year when the thermic

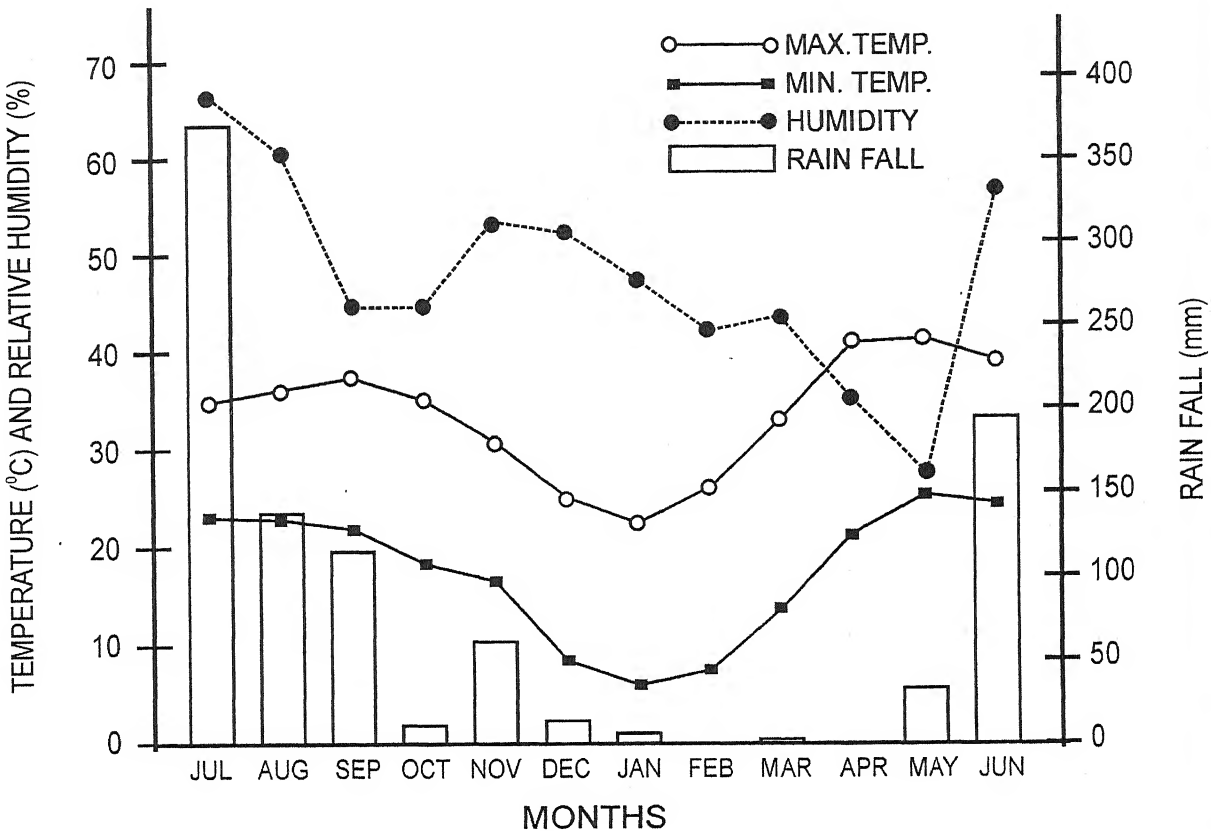

Fig.2.2A: Climatic Condition of Orai (2002-2003)

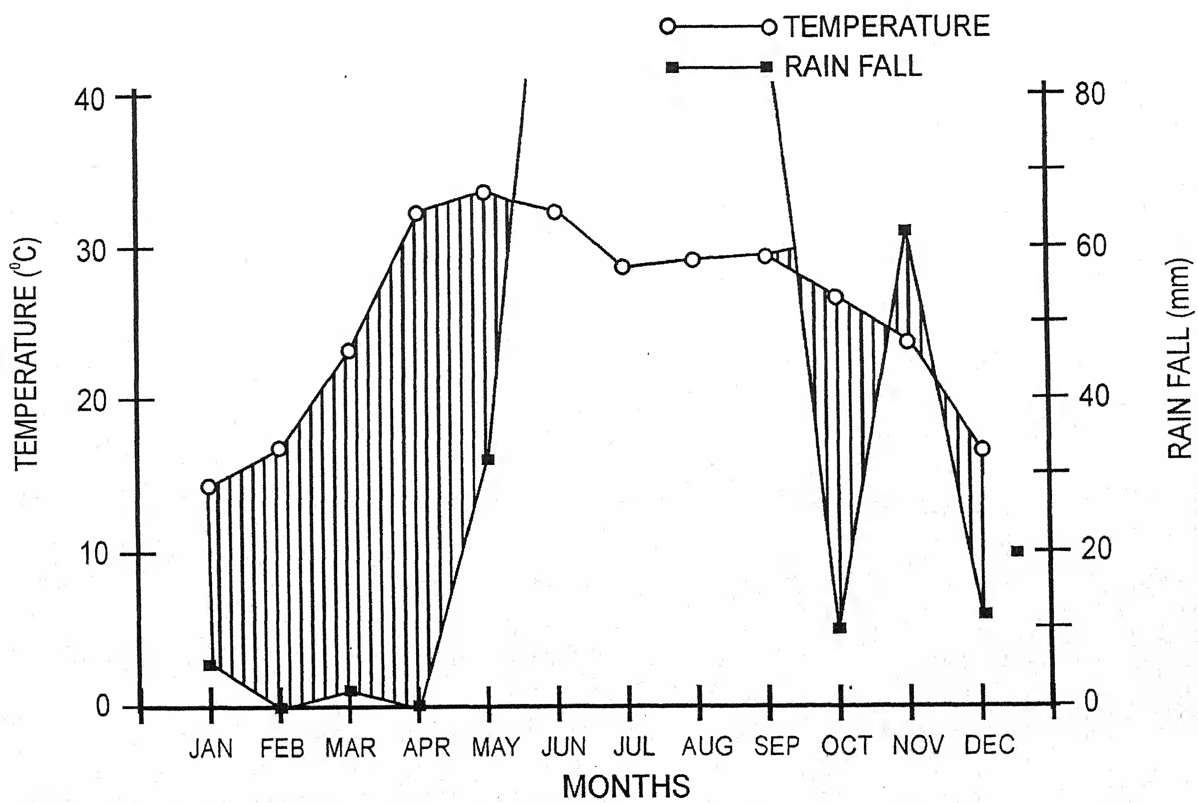

Fig.2.2B: Ombrothermic Diagram of Orai

curve remained above the Ombric curve. Rest of the months were wet and heavy rains were recorded mostly from last part of June to September

Water Balance Computation

Water is a basic need of all organisms. In nature it exists in three different physical forms. The major sinks are ocean, ice caps of the mountain and poles, underground, lakes, rivers etc. Precipitation imparts a small fraction of it which keeps the land surface moist. Water supply on land, its utilization by living organisms and ultimate return to major storage pools keep on operating in nature through the hydrological cycle. A systematic analysis of this income and expenditure of water in any particular region known as "Water balance compuation" lies in the moisture content of the soil which supports vegetation growing over it.

Following the method of Thornthwait and Mather (1955) the water balance computation sheet of the study area for the year July, 2002- June, 2003 has been prepared (Table 2.2). Fig. 2.3 shows the water balance computation graph which has been drawn with the help of average precipitation, potetial evapotranspiration and actual evapotranspiration increase with an increase in the atmospheric temperature and decrease with increasing the relative humidity of the region. Actual evapotranspiration is governed by the

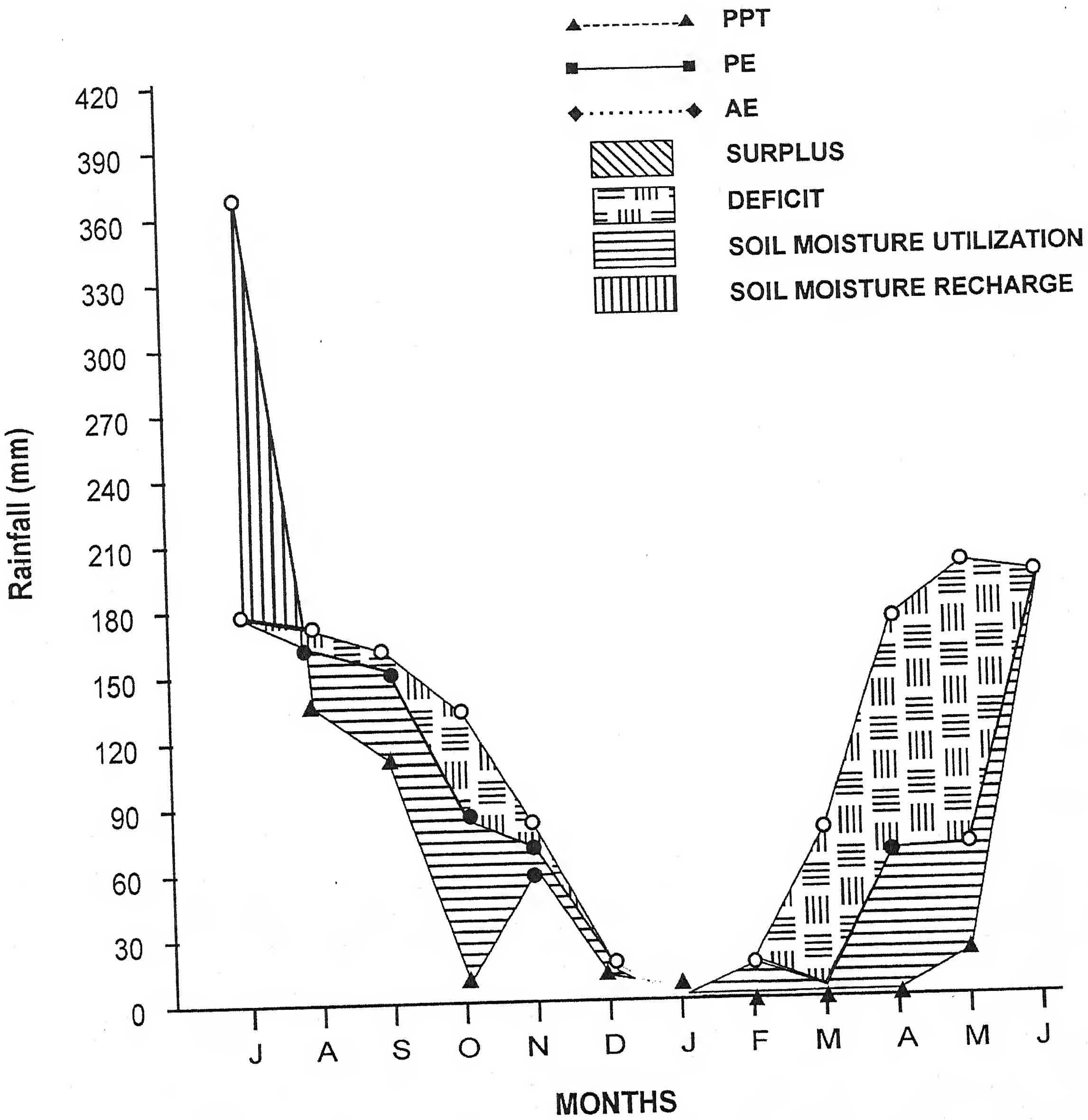

Fig.2.3: Water Balance Computation for Orai (2002-2003)

Table 2.2: Water balance computation at Orai (2002-2003)

Lat. N 25°59' 30" **Long. E 79°3' 30" at 141.61 m a.m.s.l.**

	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Average Annual
T°c	28.87	29.06	29.54	26.62	23.83	16.89	14.28	16.80	23.23	31.14	33.44	32.20	
i	14.24	14.39	14.69	12.56	10.62	6.32	4.91	6.26	10.21	15.92	1.73	16.78	144.63
UPE	15.45	15.61	15.89	13.59	9.00	21.00	-	21.00	79.00	16.85	17.88	17.39	
P E	180.7	174.8	162.0	134.54	81.9	19.11	-	18.69	81.37	178.6	205.6	198.2	1435.42
P (mm)	371.2	136.4	115.2	10.4	62.1	11.8	5.3	0.00	1.8	-	33.0	194.5	941.7
P-PE=Δ	190.5	-38.4	-46.8	-124.1	-19.8	-7.3	5.3	-186.9	-9.5	-178.6	-172.6	-3.7	
Σ Δ	190.5	-38.4	-85.2	-209.3	-229.1	-236.4	5.3	-186.9	-1.964	-375.0	547.6	551.3	
St	237.5	264.0	225.0	149.0	139.0	136.0	141.3	160.0	155.0	85.0	47.0	47.0	
Δ St	190.5	26.5	-39.0	-76.0	-10.0	-3.0	5.3	18.7	-5.0	-70.0	-38.0	0.0	
AE	180.7	162.9	154.2	86.4	72.1	14.8	-	18.69	6.8	70.0	71.0	194.5	
W D	-	11.9	7.8	48.14	9.8	4.31	-	-	74.57	108.6	134.6	3.7	403.42
W S	-	-	-	-	-	-	-	-	-	-	-	-	
R O	-	-	-	-	-	-	-	-	-	-	-	-	

T°C = Mean monthly temperature
i = Heat index
U P E = Unadjusted potential evapotranspiration
P E = Potential evapotranspiration
A E = Actual evapotranspiration
P = Mean monthly precipitation

Σ Δ = Summation data (Potential water loss)
St = Storage
W D = Water deficit
W S = Water surplus
R O = Run-off

water available for plant growth and soil moisture storage. In the rainy season, when there was sufficient water for plant growth and soil moisture storage, the rate of actual evapotranspiration was found maximum by the end of rainy season (i.e. during October) when precipitation was less than potential evapotranspiration, a decrease in the rate of actual evapotranspiration was recorded and this decrease continued till April except a few exceptions due to occasional rains.

It is evident from Table 2.2 that soil moisture was being utilized by actual evapotranspiration in all the months excluding July. This utilization was maximum in June and minimum in January. As a result of this process, water deficiency was recorded in most part of the year. In the month of July when precipitation exceeds potential evapotranspiration, the excess of water was totally spent in soil moisture recharge. It is worth noting that there was no water surplus during the study year. According to Thornthwait system, based on soil moisture index value (-16.86) the present study area can be classified as dry sub-humid (C_1) which can be further classified on the basis of thermal efficiency, i.e. PE (=1435.42 mm) as micro-thremal (0-3 C_1). The value of summer concentration of thermal efficiency (S C T E = 40.57) comes to a'_3 symbol which clearly indicates that lower S C T E value means, high temperature uniformally month after month. Thus, ecoclimatic

formula of the study area comes to C_1 C_2 a'_3 d where small d indicates no water surplus.

The various climatic indices worked out are :

Potential Evapotranspiration (PE) = 1435.42mm

Humidity Index

(Ih) = S/PE x 100 = 00

Aridity Index

(Ia) = D/PE x 100 = 28.10

Mosture Index

(Im) = Ih - 0.6 (Ia) = -16.86

Summer Concentration of Thermal Efficiency (SCTE) = 40.57

Soil

Soil is an useful resource to the man and is a component of environmental system. Thus it can be studied in terms of link between soil properties and process and other environmental components such as air, water, rock and life. In addition, the soil properties and processes which affect the use of soils by man are important topics for study. Soil develops when rock at the surface of the earth is changed by a series of processes, collectively known by the terms weathering. The rock is weathered and broken down by the combined action of water, gases and living matter. The formation of soil is not just a matter of the disintegration of rock:

while the rock is disintegrating it is exchanging material with its immediate environment. A true soil is, therefore, a rock which has exchanged some material with its environment and the soil now incorporates not only rock but also water, gases both living and dead organic matter.

Soil conditions have a considerable influence on plant growth but often plant growth can not be thought of solely in terms of soil conditions. Other factors are also involved, such as genetic constitution of the plant, the climate, competition between different plants and infestation by viruses and fungi. Any one of these factors may limit the growth of plants. It follows that maximising plant productivity, in an agricultural context, or understanding plant distributions, in an ecological context, involves the study of many factors, not simply soil factors. Indeed, for many semi-natural vegetation types man has been the dominant influence. On the occurrence of plant species rather than environmental factors. Soil conditions should, therefore, be seen as one of many contributing factors influencing agricultural crop production and influencing plant ecology.

Plants may also have a significant influence upon soil characteristics. In particular, the nature and acidity of leaf litter can strongly influence the nature of the humus layers in soils which act to influence soil properties such as infiltration capacity. Plants may

also influence the nutrient status of a soil, depleting it by nutrient uptake at the roots. Soil of the study site presents a mature profile development. It is an old alluvial deposit. Agrawal and Mehrotra (1952) classified it as soil type III.

MATERIALS AND METHODS

Soil samples were collected from studied grassland at the depth of 0-30 cm at each sampling dates of study period. Composite soil samples of each sample were taken for the analysis of all physical and chemical parameters of soils of grassland. All the analysis were done at air dried basis, i.e. room temperature. The soil samples were passed through a sieve having 2mm holes in order to avoid the rootlets and stones.

Soil Colour

It was estimated with the Munshell soil colour chart. Nomenclature for soil colour was expressed in colour names and Munshell notation recommended in the chart.

Soil Moisture

Fresh soil samples were taken in the beaker and dried at 105^0C for 24 hours. The loss of moisture in fresh weight was calculated on the dry weight of soil (Misra, 1968).

Soil Texture

It was performed by International Pipette Method as described by Piper (1966).

Field Capacity, Water Holding Capacity, Bulk Density and Porosity

It was estimated by methods described by Misra (1968).

pH

It was made by pH meter having glass-electrodes in a 1:5 soil water suspension (Misra, 1968).

Organic Carbon

It was estimated by Walkley and Black's rapid titration method as described by Piper (1966).

Nitrogen

It was analysed by Micro-Kjeldahl method as described by Jackson (1958).

Available Phosphorus

It was estimated photometrically by the molybdophosphoric acid blue colour method as given by Jackson (1958).

Exchangeable Cations

Exchangeable cations, i.e., potassium, calcium, acid sodium

were extracted by leaching the soil with the adequate amount of neutral ammonium acetate solution. The concentration of the nutrients was estimated by Flame-photometer using different filters. i.e., potassium, calcium and sodium as described by Jackson (1958).

RESULTS

The physical properties of grassland soil is given in the Table 2.3. The colour of the soil was light gray on dry but olive brown on wet. The texture of the soil was sandy loam. The percentage of sand, silt and clay were estimated 55.08, 27.10 and 17.81, respectively. The percentage of the sand was comparatively higher than silt and clay. The moisture content. bulk density. porosity. water holding capacity and field capacity are tabulated in the Table 2.3. The chemical properties of grassland soil, i.e.. organic carbon, C/N ratio, pH, exchangeable cations are tubulated in the Table 2.4.

DISCUSSION

The physical and chemical parameters of grassland soil are greatly affected by growth and development of vegetaion. However, the significant effect of physical parameter of soil can be seen after longer period of time. Moisture content of the soil is dependent on the rainfall (Table 2.1). The bulk density was

Table 2.3 : Soil colour, texture class, mechanical composition, moisture, bulk density, porosity, water holding capacity and field capacity of soils of grassland.

Physical Properties		
1. Colour	:	Light gray 2.5 Y, 7/2 dry Olive brown 2.5 Y, 4/4 wet
2. Texture class	:	Sandy loam
3. Mechanical composition		
(a) Sand (%)	:	55.08 ± 1.09
(b) Silt (%)	:	27.10 ± 0.48
(c) Clay (%)	:	17.81 ± 0.33
4. Moisture content (%)	:	10.36 ± 0.42
5. Bulk density (g/cc)	:	1.37 ± 0.05
6. Porosity (%)	:	47.31 ± 1.88
7. Water holding capacity (%)	:	46.09 ± 1.85
8. Field capacity (%)	:	29.03 ± 1.17

Table 2.4 : Organic carbon, total nitrogen, C/N ratio, pH, exchangeable potassium, calcium, sodium and available phosphorus of soils of grassland.

Chemical Properties		
1. Organic caron (%)	:	0.39 ± 0.02
2. Total nitrogen (%)	:	0.03 ± 0.001
3. C/N ratio	:	13.00 ± 1.46
4. pH	:	7.30 ± 0.28
5. Exchangeable potassium (m.e.%)	:	0.42 ± 0.03
6. Exchangeable calcium (m.e.%)	:	3.31 ± 0.20
7. Exchangeable sodium (m.e.%)	:	0.16 ± 0.01
8. Available phosphorus (ppm)	:	126.00± 6.17

recorded 1.37 g/cc and as a general rule porosity is found to be inversely related to bulk density. The clay particle of the soil is more or less related to water holding capacity and field capacity (Sant, 1966; Pandey and Sant. 1979). Man and Biosphere programme sponsored by UNESCO has given much importance on the carbon, nitrogen status of the soils. The main source of carbon and nitrogen in the soil is litter and decaying roots. Therefore, high amount of organic carbon was recorded on the soil due to low decomposition in the soil having more moisture liberating much amount of nitrogen which was lowered the C/N ratio indicating slow rate of decomposition (Foth and Turk, 1972). The pH of the soil was found neutral on the soil. It may be due to faster decomposition of litter and formation of humic and fulvic acid. Most of the nutrients exist in minerals and orgaic matter and as such are insoluble so unavailable to plants. Nutrients become available through mineral weathering, organic matter decomposition and precipitation. The nutrients are abosorbed from the soil solution or from colloidal surfaces as cations and anions. All the exchangeable cations were in high concentration because of addition of elements released by litter decomposition. The soil contained least amount of phosphorus as compared to other major nutrients. Less amount of phosphorus is required in the plants in comparison to other macro nutrients.

CHAPTER - III

BIODATA, PHYTOGEOGRAPHY AND ECONOMIC IMPORTANCE

BIODATA, PHYTOGEOGRAPHY AND ECONOMIC IMPORTANCE

INTRODUCTION

Alysicarpus is a leguminous genus belonging to the tribe Hedysareae of sub-family Papilionaceae (or family Fabaceae) commonly called as tribal pulse. Several species are cultivated as fodder and hence, during the last three decades, the tribal pulse have been under intensive investigation at several stations of the world over with respect to development of new and improved strains. Some of the immediate goals before the plant breeders have been those of increased yield and improved forage quality.

History

There appears to be a great confusion regarding the number of species in the genus as well as their taxonomic status. Based on ecogeographical charaters and study of the polymorphism of species, Duthie (1903), Nilsson-Leissner and Trumble (1953), Willis (1957) and Hutchinson (1964) gave 7 as the maximum number of the species of the geus (Table 3.1). Probabaly many of them may be synonyms of the others. It has been pointed out by Irwin (1968) that there are various nomenclatural problems offered and these, of course, are merely reflective of the tangled biological problems posed by the genus. The complexity is so much

compounded that he doubts if one can make sound reference to any speies of *Alysicarpus* without first undertaking a thorough taxonomic study.

Distribution

Alysicarplus Neck is a moderately small herbaceous genus comprising of 7 species (Table 3.1). The taxon belongs to the old world (Suvorov, 1950) and is confined primarily to the subtropical zone of the Northern Hemisphere. Some species, however, are also distributed in the temperate region. *Alysicarplus* occurs wild in the USSR almost obiquitously, its northern distribution limit nearly coinciding with the extreme limit of any agricultural activity (Bobrov, 1939). The genus is widely distributed throughout Eurasia, especially in the Mediterranean (Airy Shaw, 1966) and along the coastal belt of the northern, eastern and western parts of Africa. *A. monilifer* has spread in north western direction throughout Eurasia (Schulz, 1901). *A.rugosus* however, differs in the respect that its distributional area extends upto China and Japan (Kitamura, 1960) and thus seems to have spread gradually to the warmer parts of the tropical zones of the globe (Fig 3.1).

Two important forage yielding species, viz., *A.monilifer* and *A.rugosus* are now widely distributed in grassland throughout the world and alongwith other species have become

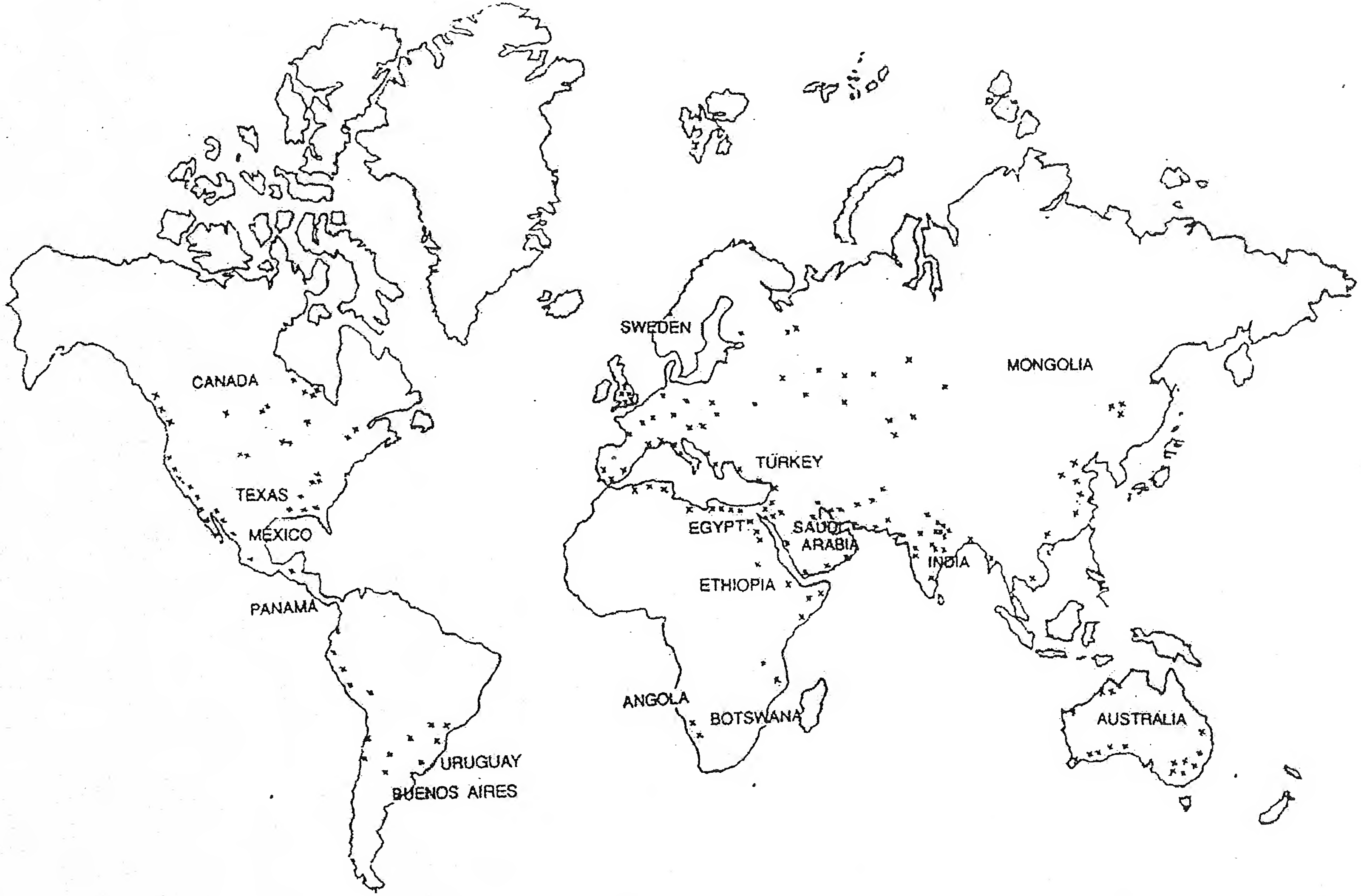

Fig. 3.1: Map showing distribution of *Alysicarpus* species

Table 3.1 : Geographical distribution of *Alysicarpus* species.

Suborder	:	Papilionaceae (Fabaceae)	Calyx-segments united above the level of the disk, the upper petal (standard) exterior, stamen for 2-adelphous, pods dehiscent along both sutures.
Tribe	:	Hedysarae	Pods breaking into 1-seeded indehiscent segments or if dehiscent opening along lower suture only.
Genus	:	*Alysicarpus* Neck.	Throughout the tropics of the old world.
Species	:	*A. monilifer* DC.	Throughout the tropics of India and Ceylon and Burma, extending to Nubia and Abyssinia.
		A. hamosus Edgew.	Bundelkhand, Guna, Panjab, Sind, Bihar, Central Provinces and West and South India.
		A. vaginalis	West Himalaya upto 4,000 ft. and throughout India from the Panjab plain to Ceylon and Malay Penins, also in Afghanistan and throughout the tropics of the old world.
		A. bupleurifolius DC.	Throughout India and Ceylon, ascending to 4,000 ft. on the Himalaya: also in the Malay Islands, China, Philippines, Mauritius and Polynesia.
		A. longifolius W.kA.	Throughout the plains of India and Ceylon, Dehradun, N. Oudh, Bundelkhand.
		A. rugosus DC.	Dehradun, Rohilkhand, Bundelkhand Merwara, Himalaya upto 4,000 ft. and south to Ceylon, also in Burma: tropical regions of the old world, also at the cape and in the W.Indies.
		A. tetragonolobus Edgew.	Jamuna ravines near Etawah and in Bundelkhand and West India.

Phytogeography

The distribution of a taxon over the surface of the Earth is a profitable study only if it is accompanied by some prior concepts as to the time and place of origin (smith. 1969).

Origin and Evolution

According to Suvorov (1950) the appearance of *Alysicarpus* is apparently referable to the Upper Tertiary period, to Miocene or even Pliocene. There is enough evidence that the present three climatic regions in temperate Europe were distinct throughout the Pliocene and their floras being indeed at least as different as they are today (Szafer, 1946-47). He further maintains that in Miocene the Mediterranean flora had already many of its present peculiarities, and the climate was also uniform throughout.

In absence of direct paleobotanical evidence drawing any conclusion regarding the genesis of the genus is difficult. Reid and Chandler (1923) have reported its fossilized seed in the Interglacial flora of Clacton-on-sea. U.K.. belonging to middle Interglacial period of Pleistocene epoch of Quaternary.

Alysicarpus was used as a green manure crop by the ancient Greeks in the Mediterraneam region 2000 years ago (cf. Wolfe and Kipps, 1959, Martin and Leonard, 1967). It might have existed wildely in the old world since pre-histori times. It would,

therefore, not be improper to speculate its evolutionary history parallel to ancient crop plants which originated in western Asia. According to Hutchinson (1965) the estimated period for the evolution of the oldest crop plants is about 9000 years. He considers the same antiquity for most of the forage plants as well for which the wild progenitors and the cultivars are still found side by side. The choice of wild plants for domestication generally depends upon their immediate attractiveness and usefulness. Of those initially selected only a few are successful and have spread; and these only persist so long as they maintain their place in competition with other corp plants.

Centre of Origin

There are various views regarding the place of origin. Ahlgren (1956) has envisaged it somewhere in Eurasia while Hector (1936) holds that the various species are natives of Europe, Asia and Africa. Schulz (1901) suggests the biennial group to have originated in the arid plains of south western Asia. A few workers view the genus to be native of temperate Eurasia (Smith, 1953). while others maintain it to be of south eastern Europe (cf. Encycl. Brit., 21, 1959). Klages (1958) and Wolfe and Kipps (1959) visualize western Asia, or Asia Minor (cf. Martin and Leonard, 1957; Nilsson-Leissner and Trumble, 1953) as its land of origin.

Suvorov (1950) regards the genus to be of ancient Mediterranean origin.

A true picture on the subject may be obtained on analysing the various aspects of distribution. Table 3.2 shows that almost all the biennial species are represented in different parts to Europe, where other species are strongly rooted in the mediterranean region. The position of the distribution of *Alysicarpus* species is further clarified from their region-wise occurrence given in Table 3.2.

Table 3.2 : Regionwise distribution of *Alysicarpus* species.

Region	No. of species Occurring	percent endemism
Eastern Europe including Russia	11	18.2
Western Europe	5	-
Entire mediterranean	13	23.0
Mediterranean Europe	10	-
Mediterranean and other parts of Africa	8	25.0
Mediterranean and south western Asia	10	10.0

The first and the foremost criterion and consideration regarding the question of the centre of origin has been in favour of a region where a genus has maximum number of species (Polunin, 1960; Turrill, 1964). Cain (1944) considers that it is possible from

the distribution patterns and phylogenetic relationships to ascertain the centre of origin of a taxon, and the concept of area includes centre of origin, centre of development (maximum variation) and centre of frequency.

It may be noted that a great majority of *Alysicarpus* species display circum-Mediterranean distribution and many of them occupy comparatively a wider range of habitats in the Mediterranean than in any other region. The species exhibited conspicuous variability in form and have produced a large number of 'ecotypes' in this region (Suvorov, 1950). Comparatively a larger number of endemics are also confined to this area (Table 3.2).

It would be worthwhile to consider the centre of origin and distribution reported for other members of the tribe Hedysareae. According to McLean and Ivimey-Cook (1956) the genus *Ougeinia* is essentially a Mediterranean one. *Trigonella* is mostly Mediterranean and has spread from the Mediterranean northwards into the central Europe. *Alhagi* occurs especially in the Mediterranean (Core, 1955). *Zornia* has the highest species concentration in the mediterranean region (Cooper, 1965) and is believed to have originated in those countries that border the Mediterranean and the Red Sea (Fergus and Hollowell, 1960).

Vavilov (1951) maintains that the Mediterranean centre has given rise to a number of tribe pulse. Moreover, extensive collections of forage plant seeds made by explorers in the Mediterranean region invariably contain seeds of various species of tribe pulse.

Further evidence is gaind from the process of self fertility and the seed coat dormacy etc.. rendering *Alysicarpus* species suitably adapted to the Mediterranean environment as would be discussed later. Vegis (1967) has pointed out that dormancy is of high value for the survival of the species under the environmetal conditions which prevail where the species or variety orginates.

Thus, the foregoing discussion lends support to the view that the genus *Alysicarpus* primarily originated in the Mediterranean region. Later on the taxon seems to have migrated to other parts of Eurasia and established a secondary centre of dispersal in eastern Europe. The facts that the species display a wide range of distribution in the Mediterranean and adjacent territories from west to east (Madeira to Iran) and a few are also endemic to certain areas, corroborate the view put forth by Suvorov (1950) that the genus is of ancient Mediterranean origin.

Migration, Speciation and Dispersal

Lines of migration radiating from the Mediterranean region can be traced in some directions. Chaterji (1947) maintains that a land connection existed between western Asia and southern Europe and the countries surrounding the eastern basin of the Mediterranean and part of west Asia played an important role in the distribution of fauna and flora in Europe and Asia. Further, the fact that there had been circum-Mediterranean routes for the migration of numerous species has been shown by the presence of a good number of plant common to western Asia and the Balkan penninsula. Intermediate (transitional) phytochoria (phytogeographical units) between the Mediterranean and central Europe have also been shown (Turrill, 1929. 1964). Thus, the taxon could have reached central Europe through one possible route of migration which passed from Balkan penninsula. Chulz (1901) opined that *A. monilifer* and *A.rugosus* were introduced in middle Europe perhaps in historic times by migrating people. Conquests and already trading could have moved *Alysicarpus* from the Mediterranean to other countries of Eurasia.

Migration to eastern Europe and Russia could be enviaged through high lands of Caucasus and also through Iran and once the taxon was established in this region. perhaps a secondary centre of its dispersal was formed.

In response to changed ecological conditions in a different geographical region during migration the newly arriving species were subjected to 'natural selection' and consequently, most of these adapted and adjusted accordingly by modifying their habit from annual to perennial and mode of fertilization from self to cross one. That these adaptations could have been incorporated in the migration species is supported by recent studies (Smith, 1927: Clarke, 1935; Sperbaur *et al.*, 1962).

As a sequal to migration, speciation usually follows within the genus in response to the changed environments. The environment, varying over area and through time, is a complicated factor which evokes variation in physiological capacity of individuals of a population (Mason, 1954). It is known that the plants undergoing active speciation are also capable to extensive mirgration. As the secondary centre of dispersal of the taxon lies in eastern Europe low temperature coupled with varying photoperiod of the temperate region may be responsible for initiating change in the habits of the immigration species and thus bringing about speciation in the genus.

A concept of 'genorheitron' and orderly dispersal is fundamental to scientific phytogeogrpahy (Croizat, 1952). The plasticity of the gonorheitron is evidenced from the fact the several species of *Alysicarpus* have arisen in areas of primary as well as

secondary origin in the Mediterranean and eastern Europe, respectively. The evolution potetial is displayed by the large number of species, subspecies and varieties delivered along the course and places of migration.

Another factor that might have played role in speciation is hybridization. There have been a number of reports of natural hybrids in *Alysicarpus* (smith and Gorz, 1965). Studies of inter-specific hybrids within the genus (Smith, 1954; Webster, 1950, 1955 and Jochimsenn 1964) have shown that hybridization is always in process of nature. Suvorov (1950) maintains that specific ecological conditions on the one hand and feasibility of hybridization process on the other have given rise to a new and younger branch of the genus.

It is interesting to note that *Alysicarpus* species are not equipped with any special mechanism for trans-continental and trans-oceanic distribution; yet the taxon covers a wide range of distribution area. Heinitz (1915) listed 3 species of *Alysicarpus* from Sweden raised from seeds in horse dung. Many species have probably spread as grain introductions in various parts of the world as Dunn (1905) observed in case o *A.monilifer*. Obviously, human agency has been directly or indirectly responsible for distribution of the species across seas and also through land barriers (Schulz, 1901; Wulfe, 1943; Polunin, 1960).

Mediterranean stock of the taxon is principally selffertilized. According to Stebbins (1957) this mode of fertilization may have also played some role in long distance dispersal of the taxon.

Alysicarpus rugosus DC.

A. rugosus occurs as a legume of grassland throughout the world (Map3.1). It has appeared often abundantly and most probably as a grain introduction in various parts of the world (Dunn, 1905). It is well adapted to north Indian plains and ascends upto 1200 m in the western Himalayas (Bamber, 1916; Saxena, 1963). Though confined mostly to grass fields, its habitat extends to sandy soils of the sea-shore in the Mediterranean (Eig, *et al.*, 1948) and King Island, Tasmania (Robinson, 1937), low-lying land in Iran (Rechinger, 1964), meadows and river valleys in humid steppe's in the USSR (Vassilczenko, 1968), roadsides, pathways and hills in California (Howell, 1949), rail roads and fence rows in the united States (Irwin, 1968).

A.rugosus has long been induced in grassland in India to enhance the quality of forage crop (Wealth of India, Raw Materials, vol.6, 1962) and it extensively grown in the south west Arizona. It occasionally escapes from cultivation (Kearney *et al.*, 1951). In fact, it has been introduced and established in so many areas from

America to Australia that it is now well high cosmopolitan in its occurrence (Salisbury, 1961).

Geographical Distribution

A.rugosus is distributed in subtropical and temperate regions of the old world. In Europe it is found in the Mediterranean region and south west Europe. It has naturalized in central and north western Europe. As a native it grows in Albania, Acores (Azores), Balearic Islands, Corse (Corsica), Kriti (Crete), France, Greece, Spain, Italy, Jugoslavia, Portugal, Surdegna, Sicilia (Sicily) and Turkey. It also occurs in Austria, Belgium, Czechoslovakia, Germany, Switzerland, Netherlands (Tutin *et al.*, and Poland (Trzcinska-Tacik, 1967). In Britain the plant has been recorded in 57 vice countries (Clapham *et al.*, 1958) to 75 vice-countries (Perring and Walter, 1962), mainly in south England and Wales and has naturalized in fields and waste places. It is distributed in some parts of north Africa. In Egypt, it grows as a weed in fields on way-sides (Muschler, 1912). In Asia the species is widely distributed from the Mediterranean Coast to Japan. It grows almost all over Israel, especially in middle Jordon valley, as a very abundant weed in wet fields (Eig *et al.*, 1948). In Iraq it occurs in lower Mesopotamia (Boissier, 1872; Zohary, 1946) and in Iran it is distributed in south west provinces and also in eastern part in Zabol (Davatchi, 1968). It also grows well in Asia Minor, Syria and Sinai

(Post, 1932), Saudi Arabia (Blatter, 1936), Caucasus, Central Asia, Afghanistan, Pakistan, India, China (Kitamura, 1960, Suvorov, 1950) and Japan (Jisaburo, 1965).

A.rugosus was introduced in the New world where it has naturalized as a common legume in the south western United States and the lower Pacific coast (Isley, 1954: Hughes and Henson, 1957). It is one of the forb indicators in Bunch Grass Prairie in California (Clements, 1949). Records in the New York Botanical Garden herbarium (Irwin, 1968) show its distribution in the following countries :

Canada (Southern region only, mainly in British Columbia) USA (generally distributed), Mexico (south to Michoacan and Vera Cruz, with one specimen from Chiapas), Bermuda, Columbia, Ecuador, Peru, Bolivia, Chile, Argentina, Uruguay, Paraguay, and Southern Brazil (north to Sao Paulo). There appears to be a gap in distribution between southern Mexico and the Andes in Columbia. No specimen has been collected from the West Indies.

Distribution in India

The species is distributed throughout India from north to south and east to west. It occurs abundandly as a legume in grasslands from Punjab to Bengal, in Rajasthan and Madhya Pradesh (Nairne, 1894; Duthie, 1903; Gamble, 1915; Bamber, 1916;

Collett, 1921; Keoyer, 1924 and Santapau, 1953).

The information on distribution of the species gathered from various herbaria of Botanical Survey of India, National Herbarium, Calcutta and field trips to several places in Uttar Pradesh and neighbouring states has been shown in Fig. 3.2.

The other species of *Alysicarpus* found in India are *A. monlifier* and *A.hamosus*. The latter is restricted in distribution and has been occurring at 3000 m to 4000 m in Nubra and Ladak (Hooker, 1879). *A. monilifer*, except being more robust and longer, resembles *A. rugosus* and is distributed along with it throughout the country (Hooker, 1879; Duthie, 1903). *A.monifiler*, however, ascends upto 4000 m in the western Himalays (Bamber, 1916; Collett, 1921).

Migration to India

A.rugosus is said to be the pioneer species to migrate far east to India, China and Japan from its centre of origin in the Mediterranean region (Salisbury, 1961; Zohary, 1968). There are evidences that India has ever remained the centre of distribution for its westward migration to tropical and subtropical zones in the Southern Hemisphere (Suvorov, 1950). The species extends back in the past to great antiquity. It has been described (as Vanmethika), and its pharmacological properties well recognized in the oldest

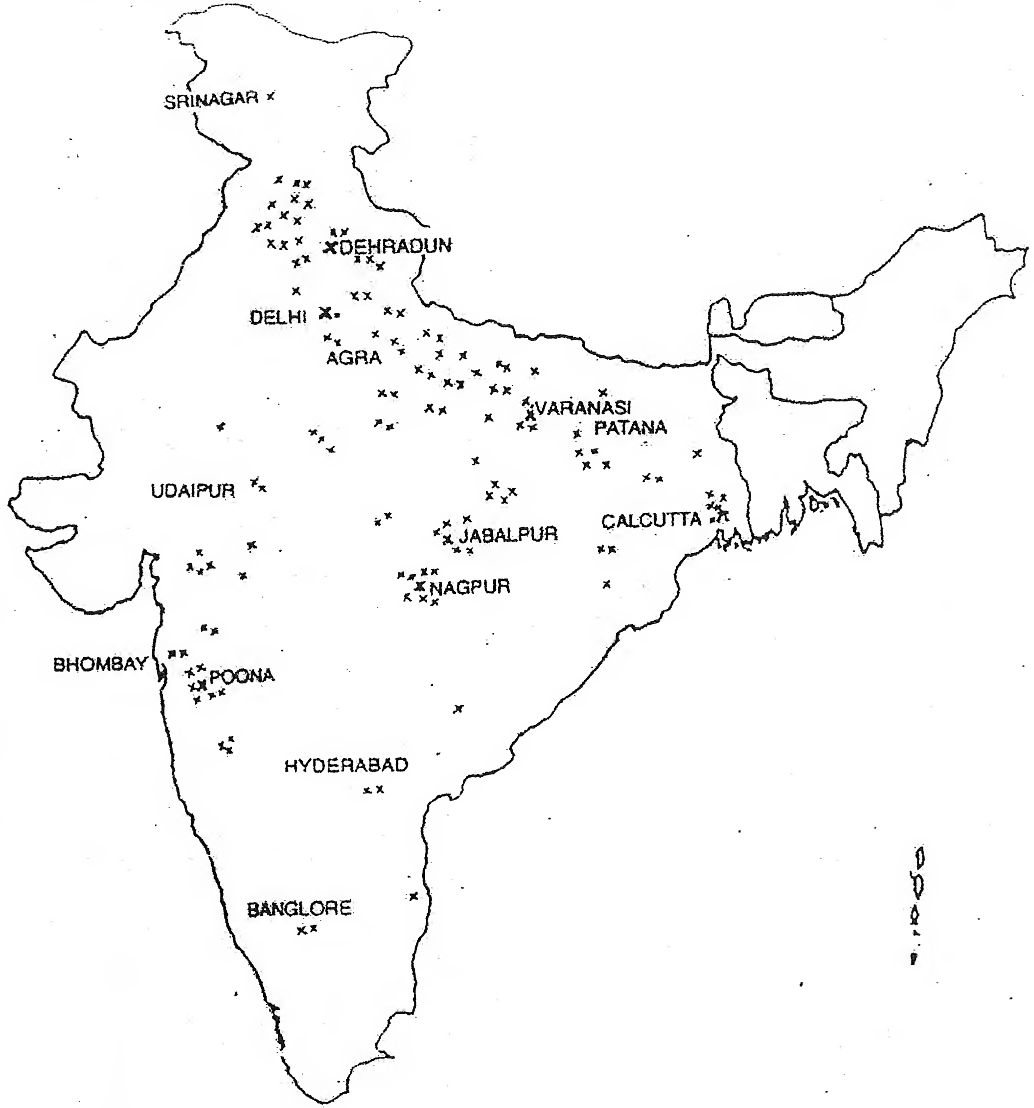

Fig. 3.2: Map showing distribution of *Alysicarpus* in India

Sanskrit medical (Ayurvedic) treatises by Charak and Sushrut some 2500 years ago (Srivastava, 1953). This indicates that *A rugosus* was well established in ancient India long back.

Morphology

Alysicarpus rugosus DC.

A considerable degree of phenotypic variability is found in *A. rugosus* which occurs in diverse conditions of habitats over wide geographical range.

A. rugosus is perennial, erect, branched herb with a number of axillary recemes, thriving well on alluvial soils.

Root	:	Tap root system having bacterial nodules.
Shoot	:	Branched, erect 30-60 cm in length.
Leaf	:	1 foliate, 1-3 in, long, on short hairy petioles, usually oblong, with a subcordate base, obtuse, apiculate, glabrous above, slightly bristly beneath the reticulate veined.
Inflorescence	:	Spike-like racemes, 1-4 in long, appressed to the subglabrous rachis.
Flower	:	Nearly sessile and dens.
Flowering	:	September to March, sometimes in early April.
Calyx	:	1/4 - 3/8 in, glabrous on the back; teeth imbricate, lanceolate, ciliate.

Corolla : Standard 3.0-3.5 mm, exceeding wings and keel.

Androecium : Didelphous.

Gynoecium : Ovary 1-2 ovuled, unilocular, style incurved, ovule campylotropous.

Pollen grains: 3-zonicolporate, subprolate, 24.5-30/.6 μ x 17.0 - 20.4 μ, colpi narrow, or more or less circular, exine 1-5 2.0 μ thick, sexine as thick as nexine, fairly reticulate.

Fruit : Pod included in the calyx, shortly stalked, turgid, apiculate moniliform, joints 2-5, broads than long, prominently marked with transverse ribs, usually one seeded, Fruiting 2- seeded. Fruiting September to April.

Seed : Ecarunculate, ellipsoidal, finely tubercled, chestnut types, albuminous, Estrophilolate, light or dark brown, possessing hard and smooth coat.

Pollination : Efficiently self pollinated. Flowers are self fertile and setting of the seed is spontaneous without insect visitation (Smith, 1953). The flowers are, however, very well suited for cross pollination.

Alysicarpus monilifier DC.

A perennial plant having branched, prostrate shoot with leaf all simple ¼-½ in long, obtuse often cordate, glabrous. Flowers shortly stalked, about 4-10 in close erect pedunculate racemes. Flowers, September-April commonly found in grassland and gardens as legume.

Economic Importance

This legume has attained considerable importance for forage and soil improvement in India and in the United States and Canada. *A. monilifer* has been used for restoring fertility to calcareous soils worn out by continuous cropping with non-leguminous crops. Its accidental introduction in the sandy soils of king Island, Tasmania, has added much to the fertility and agricultural usefulness. The legume has been selected for cultivating sandy soils in USSR, Germany and Poland and used for pasture in Argentina (Smith and Gor, 1965).

Alysicarpus is one of the outstanding legumes and has been recommended for improving alkaline soils and reclaiming saline areas (Singh, 1947; Malik, 1955). It has also been used as green manure (Idnani and Chibber, 1952).

The crop is used as green fodder. especially for drought cattle and milk cows. The chemical composition and nutritive value

of green feed, silage, hay and pods have already been worked out (The wealth of India, Raw Materials, 1962). The green fooder is particularly rich in calcium and possesses high protein percentage. Feeding trials have shown that it can be used as a maintenance ration for heifers.

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CHAPTER - IV

SEED GERMINATION

SEED GERMINATION

INTRODUCTION

Generally, crop plants have been selected for having comparatively less pronounced quiescent phase. The process of this resumption of growth of the embryo, leading to the establishment of seedling, referred to as germination, is very important in further performance of yield of any economically important plant.

As such, investigations into the physiology of seed germination of various economically important and cultivated wild plants have been receiving due attention since the very inception of agricultural civilisation (Sarin, 1961; Roberts and Abdulla, 1968; Pandey and Sinha, 1978 a,b; Datta *et al.*, 1982; Williams, 1983; Sreeramulu, 1983; Sreeramulu, 1983; Pandey and Goel, 1983; Ojha, 1984; Lallan, 1988; Sharma, 1988). Although the phenomenon of germination involves a wide array of physiological and biochemical changes within the seeds, including imbibition of water, hydration of subcellular organells, activation of enzymes, digestion and transolocation of food reserve to the embryo etc. (Noggle and Fritz, 1977), the involvement of oxogenous factors of the environment, such as moisture, light, pH and salinity of the soil, is no way less important. In this context, the temperature, air and water have long

been known to control the process. The effect of various environmental factors are quite diverse and, hence, play a significant role in adaptability and survival values of the different species under varying edaphoclimatic conditions (Crocker, 1938; Thompson, 1973; Pandey and Sinha, 1978a; Ellis *et al.*, 1982; Sreeramulu, 1983; Goel, 1983; and Ahmad, 1985).

It is true that the seeds are pretty resistant to the extremes of the environmental conditions, while lying under storage, however, the various conditions, particularly the temperature and the prevailing moisture, have profound effect on the storability, germinability and subsequently viability of the seeds (Roberts, 1960; Roberts and Abdulla, 1968; Pandey and Sinha, 1979; Ellis *et al.*, 1982; Sreeramulu, 1983; Pandey and Goel, 1983). It is generally agreed, for a variety of plants, that the lower temperature during storage maintains the viability of seeds for a much longer period (Thompson, 1970; Pandey, 1976; Ellis *et al.*, 1981; Goel, 1983), while higher temperature causes the seeds to become nonviable (Khare, 1978; Pandey and Sinha, 1978; Ellis *et al.*, 1982; Goel, 1983). Once the essential preconditions for germination are made available, the amplitude of temperature tolerance reduces greatly during the actual process (Khare, 1978, Pandey and Sinha, 1978b; Bonnewel *et al.*, 1983). The range of constant temperature pertaining to its minima, optima and maxima has been found to be

very specific for the different groups of taxa. Thompson (1973) has stressed that these temperatures are well correlated with the prevailing temperatures of the area of origin for the species. Investigations regarding such differential responses of species to the varying temperatures have recently been much attempted (Samenza *et al.*, 1978; Khare, 1978; Khare, 1978; Ellis *et al.*, 1982; Bonnewel, *et al.*, 1983; Sreeramulu, 1983). The role of visible radiation has much elucidated with regard to its association with the phytochrome activitiy during germination (Scruit and Mancinelli, 1969; Sircar, 1970; Wivell, 1983).

In many economically important plants, the initial establishment of seedling has been found to be much affected by the salinity and several stress conditions prevailing in the soil. This aspect has also received much attention recently (Sarin, 1961; Zur, 1966; Sinha, 1967; Prisco and O'leary, 1970; Pandey, 1976; Kabir and Poljakoff-Mayber, 1975; Dubey, 1982; Kole and Gupta, 1982; Singh andSingh, 1982; Goel, 1983; Singh, 1984; Kumar, 1985). At various occasions the pH of the soil also affects the germinability (Gargand Eary, 1981; Kumar, 1985). In a number of cases, the effect of various growth substances and herbicide have been observed to affect the level of hydration, germination percentage and early seedling growth (Brain and Homming, 1985; Blakely *et al.*, 1972; Pandey, 1976; Goel and Baijal, 1980; Vargava *et al.*, 1983, Nehru *et al.*, 1999).

In view of the above mentioned facts studies have been made to compare the germinability of two species of *Alysicarpus* right from early stages of maturity up to twelve month under storage with a view to understanding the nature, the extent of dormancy. Before hand their germinability at constant temperatures (0^0C-60^0C) dormancy due to presence of an inhibitor and/or absence of necessary promotor have been looked into. Hormonal substances including GA, IAA, MH etc. have been widely utilised and assessed for having their specific roles in the germination and early seedling growth. Brain *et al.* (1955), Vargave *et al.* (1983) and others (Sharma and Sen, 1974; Kumar *et al.*, 1982) have reported the promotery effect of inhibition like MIA and thiourea (Katyayani *et al.*, 1980; Agrawal, Vyas and Shrimali, 1973; Mayer and Polzakoff-Mayber, 1978) have been observed to lower the percentage and also to retard the growth of the radicle. The relationship of seed during maturation and the loss of moisture was first observed by Gill, 1938. In context of viability and maturity in many weedy seeds various workers (Sinha and Pandey, 1979; Goel, 1983; Lallan, 1988) have observed a direct relationship between the loss of moisture and development of coat dormancy in various leguminous seeds.

Since both the seeds of *A.moniiifer* and *A.rugosus* are coat dormant, in the following chapter an attempt has been made to

study the pattern of dormancy, germination and early seedling growth. The role of temperature and the storage of temperature have been investigated. Effect of water as well as salt stress due to NaCl, Na_2SO_4 and of growth substances including IAA, GA, MH and thiourea have also been studied. The effect of light (diffused red and farred), radiation was also investigated. Finally, the seeds procured at different ways of maturity were also tested for their germinability.

MATERIALS AND METHODS

Germination

Seed germination experiment were conducted in sterilized petridishes of 9 cm diameter, containing thin cotton pads covered over by filter circles (Whatman No.41). Distilled water was used as a soaking medium for seeds and filter pads except in those petridishes which were for testing the effects of stress of salts, mannitol, pH, growth hormones. As the seeds of *A.monilifer* and *A.rugosus* are seed coat dormant they were scarified before use, by pretreating with Conc. H_2SO_4 for 15 minutes in case of *A.monilifer* and 10 minutes in case of *A.rugosus* and thoroughly washed in running water for removing H_2SO_4 and insuring maximum germination. Seeds of homogenous size were selected by hand picking and surface sterilized with 5% solution of sodium

hypochlorite (for 2 minutes) and thoroughly washed with distilled water. Four replicates, each with 25 seeds were taken for each treatment. Replicates were incubated at 20 ± 2^{0}C for all treatments, except in those cases where temperature optima under different constant temperatures were to be worked out.

Constant Temperature

For finding out the temperature optima, seeds tested for their germinability at 0, 10, 20, 30, 40, 50 and 60^{0}C by placing the replicates in incubators/seed germinator maintained at aforesaid temperatures.

Storage Temperature

Effect of storage temperature was studied after storing the seeds at 0, 10, 20, 40^{0}c and at room temperature for one year and then germinated them under incubator at 20 ± 21^{0}C.

Effect of Light

Effect of different photo quality on germination was evaluated in petridishes containing seeds in seed germinator which also control the light. Effect of red and far-red were tested after wrapping the petridishes with double fold of red and blue cellophane papers, one fold each in combination for far-red spectrum were wrapped on petridishes to test the effect of far-red light on germination. Blue light was given to the seeds by wrapping the

PLATE - III : Showing germination study in seed germinator.

PLATE - IV : Showing germination study while putting the tray containg seeds into seed germinator.

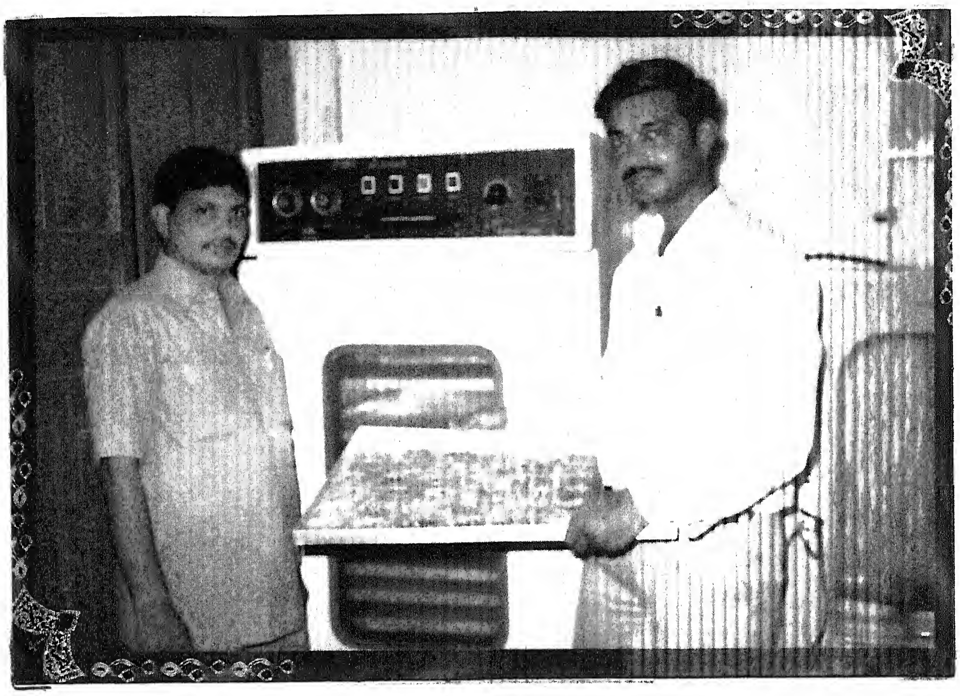

PLATE - III

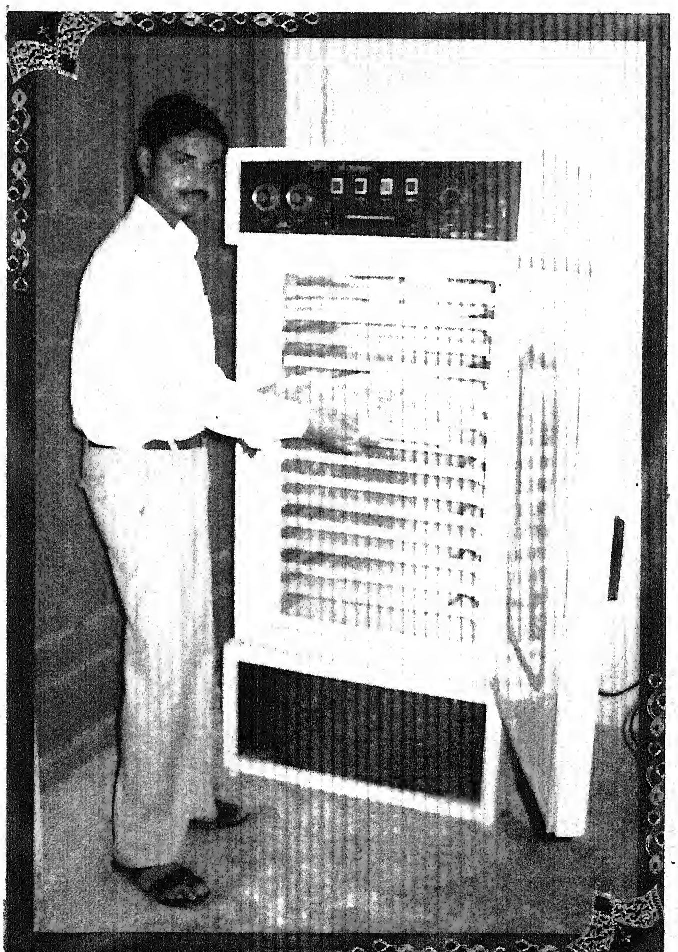

PLATE - IV

PLATE - V : Showing seed morphological study as seen under the microscope.

PLATE - VI : Showing germination studies while counting the number of seeds germinated.

PLATE -VII : Showing instruments used to take out the seeds from the fruit (pods) and so on.

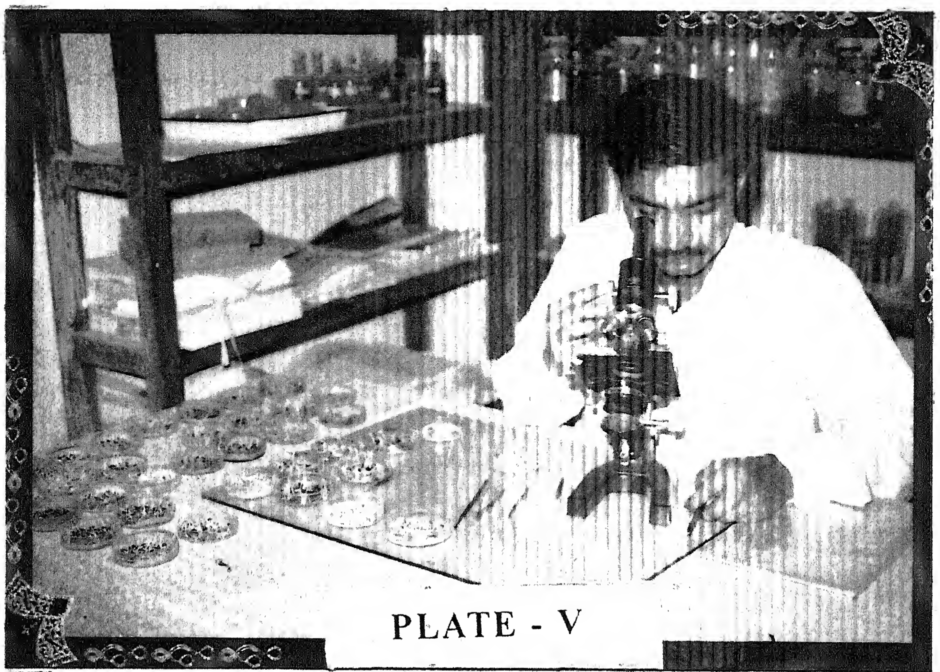

PLATE - V

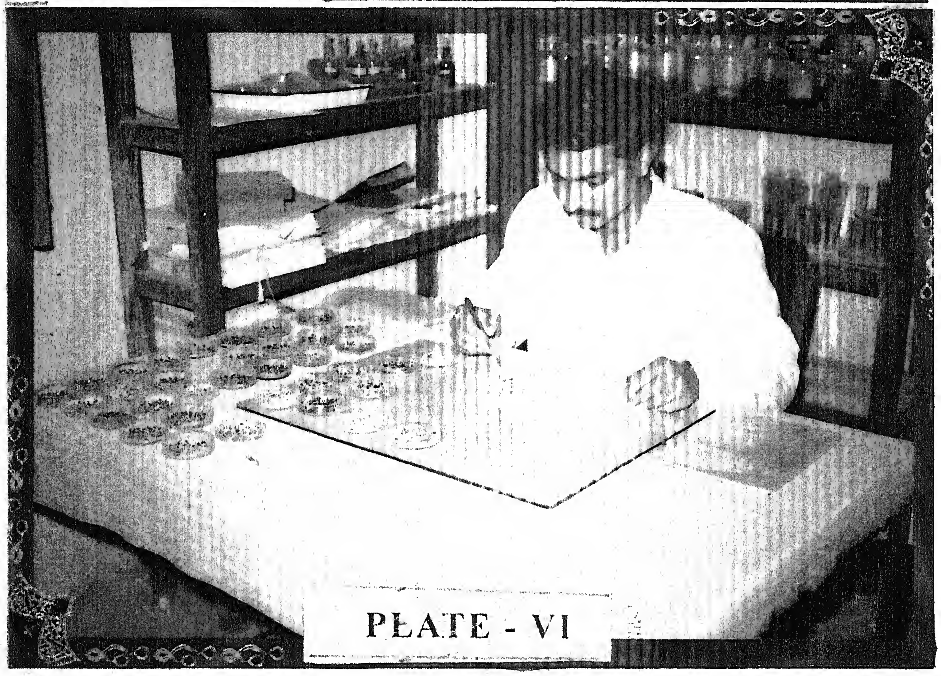

PLATE - VI

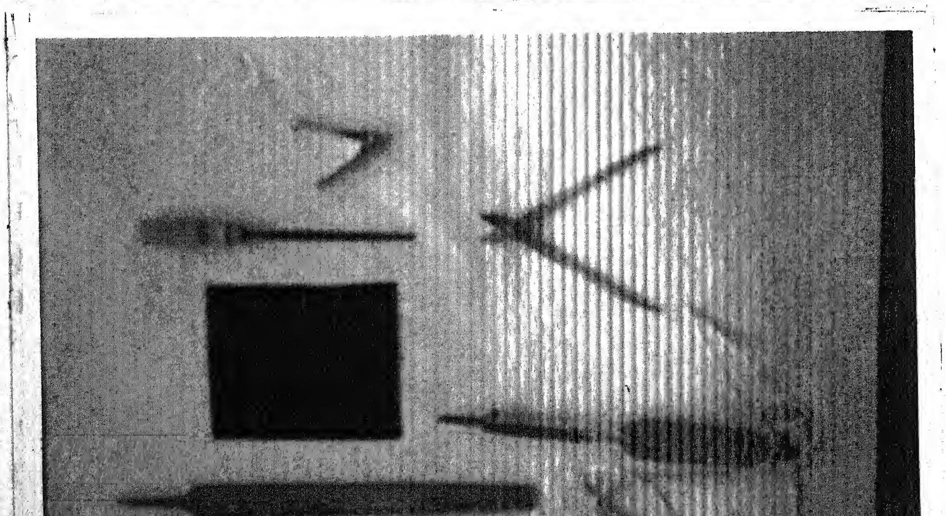

PLATE - VII

petridishes by two folds of blue cellophan papers. Complete darkness was created by wrapping petridishes with four wraps of carbon paper and by putting them in between the two folds of black cloth in the incubators. Seeds examined for effect of darkness, when once counted, were discarded for next reading due to exposure to light during counting. Petridishes wrapped with double layers of colourless cellophan were treated as control.

Stress

Effect of water stress was tested in 0.05, 0.1, 0.15, 0.20, 0.25, 0.30 and 0.50M mannitol prepared in sterilised distilled water. Stresses of NaCl and Na_2SO_4 were examined on germiantion in the concentration of 0.05, 0.10, 0.15, 0.25, 0:30 and 0.50 M solutions. Respective concentrations were used for soaking the seeds and germinating medium in all treatments except control, where sterilised distilled water was used.

Effect of IAA, GA and MH

Solutions of 1, 5, 10, 25, 50, 100 ppm concentrations each of indole acetic acid (IAA), gibberellic acid (GA) and maleic hydrazide (MH), were used for soaking the seeds and germination medium except the control, where sterilized distilled water was used.

Effect of pH

Phosphate citrate buffer countaining Na_2HPO_4 and citric acid was used in the range of 5 to 9 pH for germinating the seeds as given by Malik and Srivastava (1978).

Effect of Thiourea

Solutions of 1, 5, 10, 25, 50, 100 ppm concentrations of thiourea were used to test the germinability and distilled water was used for control.

Effect of Different Maturity Classes

For finding out the germinability of the different maturity classess, seeds of *A. monilifer* were collected from greenish, yellowish and gray pods and seeds of *A. rugosus* were collected from greenish, yellowish and dry pods. These colours of pods respectively showed increasing degree of maturity.

The seeds with visible emergence of radicles were taken as germinated (Popay and Roberts, 1970) and such seeds were scored every 24 hours till 240 hours after soaking. Mean germination percentage was calculated on the basis of replicates lenghts of radicle and fresh weight of seedling were taken after 96 hours of duration and 144 hours of duration. Initial time lag (in days) and time spread (in days) were also calculated.

TABLE 4.1: Effect of constant temperatures on the germination of *A. monilifer* and *A. rugosus*.

Attributes/ Treatments	Initial time lag (days)				Germination							
					Time spread (days)				Germinatio % at 96 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	1	1	-	1	2	2	-	8	4.0	39.0	-	11.5
0^0	8	-	-	-	10	-	-	-	-	-	-	-
10^0C	4	4	4	4	6	6	4	6	34.0	46.5	2.4	11.5
20^0C	-	2	-	2	-	2	-	6	-	89.0	-	68.0
30^0C	-	6	5	4	-	6	5	6	-	59.0	-	6.5
40^0C	-	1	-	4	-	5	-	6	-	54.0	-	9.0
60^0C	6	7	5	1	6	7	6	7	-	-	-	9.0

Contd...

TABLE 4.1: Contd.

Attributes/ Treatments	Germination % at 144 hrs				Radicle length (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	74.0	-	51.0	-	40.6	-	-	-	12.34	-	-
0^0	-	-	-	-	-	-	-	-	-	-	-	-
10°C	78.0	88.0	-		6.2	5.8	6.8	4.8	3.06	4.37	3.99	4.98
20°C	-	88.0	-		-	53.8	-	36.8	-	10.89	-	9.62
30°C	-	68.0	-		-	-	-	-	-	-	-	-
40°C	-	74.0	-		-	21.9	-	21.9	-	7.78	-	3.88
60°C	24.0	-	94.0		-	-	-	4.8	-	-	-	4.48

Contd...

TABLE 4.1: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	46.2	-	35.4	-	15.7	-	13.5
0^0	-	-	-	-	-	-	-	-
10^0C	9.6	8.1	-	6.0	5.8	4.7	-	3.5
20^0C	-	68.6	-	68.8	-	20.1	-	18.7
30^0C	-	4.1	9.1	4.2	-	2.0	8.4	0.3
40^0C	-	5.2	-	4.2	-	3.0	-	0.5
60^0C	-	-	4.2	-	2.10	-	2.0	-

NAM = Unscarified *A.monilifer*; NAR= Unscarified *A.rugosus*; SAM = Scarified *A.monilifer*; SAR= Scarified *A.rugosus*

TABLE 4.2: Effect of storage temperatures on germination and early seedling growth on *A. monilifer* and *A. rugosus* (one year old seed).

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	3	1	2	1	3	2	2	2	2.0	90.5	-	100.0
0^0	-	1	-	1	-	2	-	1	-	94.0	-	100.0
10^0C	1	1	1	1	2	2	1	1	95.5	100.0	9.5	100.0
20^0C	-	1	1	1	-	2	1	2	-	100.0	2.0	100.0
40^0C	2	1	1	1	2	2	2	2	2.0	100.0	47.0	100.0

Contd..

TABLE 4.2: Contd.

Attributes/ Treatments	Germination % at 144 hrs				Radicle length (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	94.0	-	100.0	11.5	40.1	2.0	48.5	-	4.85	-	-
0^0	-	100.0	-	100.0	-	47.5	-	54.5	-	8.10	-	9.85
10^0C	100.0	100.0	9.5	100.0	44.5	50.5	32.9	54.4	6.10	10.50	4.20	10.55
20^0C	-	100.0	4.5	100.0	-	50.6	-	54.5	-	9.25	6.88	6.75
40^0C	4.5	100.0	58.0	100.0	39.5	42.1	28.5	42.5	14.5	12.98	11.85	12.95

Contd..

TABLE 4.2: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	74.5	-	-	-	8.87	-	-
0^{0}	-	79.5	-	77.5	-	15.98	-	15.20
10^{0}C	74.5	79.6	64.5	71.5	12.8	16.95	6.60	15.20
20^{0}C	-	78.5	94.5	73.5	-	16.75	9.80	10.10
40^{0}C	64.5	77.5	74.5	72.4	20.8	18.85	20.10	16.80

TABLE 4.3: Effect of different light wavelengths on seed germination and early seedling growth.

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	1	1	-	1	4	2	-	2	-	86.5	-	94.5
Red light	1	1	3	1	1	4	3	2	4.5	86.5	2.0	96.5
Far redlight	3	1	1	1	3	4	1	2	2.0	76.5	4.5	96.5
Blue light	-	1	2	1	-	4	2	3	2.0	76.5	4.5	96.5
Dark	2	1	-	1	5	3	-	2	-	89.5	-	89.5

Contd..

TABLE 4.3: Contd.

Attributes/	Germination % at 144 hrs				Radicle length (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	4.5	94.0	-	94.0	14.0	30.0	-	31.0	2.0	56.0	-	8.00
Red light	4.5	94.0	4.5	84.0	26.0	26.9	9.0	35.0	2.0	6.0	2.0	11.0
Far red light	-	79.0	4.5	100.00	2.0	27.9	15.5	44.0	-	10.0	-	9.0
Blue light	-	94.0	4.5	100.0	1.0	15.4	24.0	90.0	2.0	7.0	-	12.0
Dark	9.5	74.0	-	100.0	-	44.0	2.0	54.0	-	16.0	-	18.0

Contd..

TABLE 4.3: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	48	48	-	40	17	20	-	16
Red light	-	58	71	68	-	23	-	20
Far red light	-	44	64	67	-	19	16	15
Blue light	-	39	54	65	-	15	14	22
Dark	46	55	-	75	8	21	-	20

TABLE 4.4: Effect of water stress (Mannitol) on germination and early seedling growth of *A. monilifer* and *A.regosus.*

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	1	-	1	-	2	5	4	-	92	-	87
0.05 M	1	1	-	1	1	5	-	6	-	89	-	74
0.10 M	2	1	-	1	1	5	-	5	2.0	82	-	92
0.15 M	4	1	-	2	4	3	-	6	2.0	84	-	82
0.20 M	2	1	2	1	2	5	6	3	2.0	92	4.0	90
0.25 M	-	2	-	2	-	4	6	5	-	84	-	84
0.30 M	2	2	-	2	2	5	-	4	2.0	76	-	82
0.50 M	6	2	-	6	6	5	-	6	-	57	-	-

Contd..

TABLE 4.4: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	77.3	12.2	68.6	-	25.42	9.65	18.46
0.05 M	84.0	76.8	-	57.5	7.70	17.70	-	13.16
0.10 M	-	56.7	-	56.4	-	12.96	-	12.26
0.15 M	-	48.6	-	45.8	-	12.61	-	9.18
0.20 M	66.0	47.2	31.5	38.3	3.50	10.52	3.88	8.25
0.25 M	-	41.2	23.0	25.1	-	10.10	3.0	5.96
0.30 M	37.0	22.0	-	41.6	3.0	5.35	-	7.86
0.50 M	9.0	13.6	-	5.0	3.1	5.06	-	4.20

TABLE 4.5: Effect of salt stress (Na_2SO_4) on germination and early seedling growth of *A.monilifier* and *A.rugosus*.

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	1	4	1	-	2	5	3	-	91.5	-	86.5
0.05 M	6	1	-	2	6	6	-	5	-	86.5	-	44.0
0.10 M	-	2	-	2	-	4	-	4	-	79.0	-	91.5
0.15 M	6	3	-	2	6	3	-	4	-	81.5	-	61.5
0.20 M	-	-	-	-	-	6	-	-		31.5	-	-
0.25 M	-	-	-	-	-	-	-	-	-	-	-	-
0.30 M	-	-	-	-	-	-	-	-	-	-	-	-
0.50 M	-	-	-	-	-	-	-	-	-	-	-	-

Contd..

TABLE 4.5: Contd.

Attributes/	Germination % at 144 hrs				Radicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	94.0	14.0	94.0	-	35.8	-	39.6	-	13.24	-	8.63
0.05 M	4.0	100.0	-	94.0	-	17.1	-	7.9	-	6.29	-	3.03
0.10 M	-	94.0	4.0	88.0	-	21.1	-	22.9	-	7.28	-	7.59
0.15 M	-	84.0	-	84.0	-	9.9	-	8.9	-	6.85	-	5.98
0.20 M	-	70.0	-	-	-	3.8	-	-	-	2.84	-	-
0.25 M	-	-	-	-	-	-	-	-	-	-	-	-
0.30 M	-	-	-	-	-	-	-	-	-	-	-	-
0.50 M	-	-	-	-	-	-	-	-	-	-	-	-

Contd..

TABLE 4.5: Contd.

Attributes/ Treatments	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	77.4	12.2	68.6	-	25.35	9.86	18.84
0.05 M	7.0	32.90	-	27.6	1.68	8.88	-	8.86
0.10 M	-	49.5	44.8	41.8	-	14.54	9.67	12.81
0.15 M	-	32.5	-	16.6	-	9.89	-	6.71
0.20 M	-	9.8	-	-	-	4.34	-	-
0.25 M	-	-	-	-	-	-	-	-
0.30 M	-	-	-	-	-	-	-	-
0.50 M	-	-	-	-	-	-	-	-

TABLE 4.6: Effect of salt stress (NaCl) on germination and early seedling growth of *A.monilifer* and *A.rugosus.*

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	2	-	1	-	2	5	4	-	92	-	86.5
0.05 M	1	1	1	1	1	4	1	2	2	92	5	96.5
0.10 M	1	1	-	1	1	2	-	2	2	94	-	100.0
0.15 M	2	1	4	1	1	6	4	3	2	87	2	100.0
0.20 M	2	2	-	2	2	6	-	3	2	80	-	92.5
0.25 M	1	2	-	2	-	4	-	4	-	47	-	65.0
0.30 M	-	-	-	-	-	-	-	-	-	-	-	-
0.50 M	-	-	-	-	-	-	-	-	-	-	-	-

Contd..

TABLE 4.6: Contd.

Attributes/	Germination % at 144 hrs				Redicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	94.0	14.0	94.0	-	35.8	-	39.6	-	13.23	-	8.63
0.05 M	-	84.0	4.0	94.0	3.0	62.6	74.0	63.2	1.28	6.74	13.20	5.36
0.10 M	-	94.0	4.0	88.0	-	21.1	-	22.9	-	7.28	-	7.59
0.15 M	4	94.0	-	100.0	-	19.6	4.0	43.2	-	3.17	1.82	8.90
0.20 M	4	94.0	-	100.0	-	15.8	-	25.7	-	3.88	-	4.25
0.25 M	-	42.0	-	94.0	-	12.4	-	34.0	-	4.92	-	6.67
0.30 M	-	-	-	-	-	-	-	-	-	-	-	-
0.50 M	-	-	-	-	-	-	-	-	-	-	-	-

Contd..

TABLE 4.6: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	77.3	12.2	68.6	-	25.42	9.6	18.84
0.05 M	-	78.0	5.9	84.5	-	25.45	-	19.46
0.10 M	-	52.0	-	88.1	-	21.52	-	19.45
0.15 M	38.0	58.3	-	47.0	9.2	16.04	-	14.92
0.20 M	44.0	23.4	-	14.6	9.5	9.31	-	7.49
0.25 M	-	15.7	-	11.2	-	4.52	-	8.59
0.30 M	-	-	-	-	-	-	-	-
0.50 M	-	-	-	-	-	-	-	-

TABLE 4.7: Effect of pH on germination of *A.monilifer* and *A.rugosus.*

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	1	1	1	1	1	1	1	2	2	94.0	2	94.0
pH-5	3	1	-	1	3	3	-	4	5	100.0	-	100.0
pH-6	3	3	-	2	3	4	-	5	2	96.5	-	80.0
pH-7	-	3	2	3	-	4	2	3	-	64.0	4	9.0
pH-8	1	1	3	2	1	2	3	2	2	100.0	-	96.5
pH-9	-	2	-	2	-	2	-	2	-	96.5	-	96.5

Contd..

TABLE 4.7: Contd.

Attributes/ Treatments	Germination % at 144 hrs				Radicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	4.0	100.0	19.0	100.0	44.0	64.0	-	78.3	3.4	6.2	-	5.29
pH-5	4.0	100.0	-	100.0	5.0	7.1	-	10.0	1.0	1.5	-	1.43
pH-6	-	94.0	4.0	94.0	8.0	7.2	-	8.0	1.6	1.2	-	2.34
pH-7	-	88.0	4.0	58.0	-	5.8	5.0	-	-	0.4	1.24	-
pH-8	4.0	100.0	4.0	100.0	-	13.2	-	14.0	-	0.5	-	4.49
pH-9	9.0	100.0	-	100.0	-	15.6	-	15.2	-	6.0	-	9.37

Contd..

TABLE 4.7: Contd.

Attributes/ Treatments	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	72.0	78.0	84.0	72.0	5.4	8.3	-	7.0
pH-5	2.0	11.0	: -	14.0	1.2	2.4	1 -	2.0
pH-6	-	9.0	-	12.0	2.8	2.2	-	5.43
pH-7	-	2.0	1.0	1.0	-	-	2.7	-
pH-8	17.0	13.0	-	12.0	-	0.7	-	6.20
pH-9	2.0	34.0	-	21.0	-	10.3	-	14.23

TABLE 4.8: Effect of IAA on germination and early seedling growth of *A.monilifer* and *A.rugosus.*

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	1	4	1	-	1	4	1	-	100.0	7	87
1 ppm	6	2	5	2	6	4	5	4	-	96.5	-	96
5 ppm	-	2	4	1	-	4	4	4	-	86.5	10	90
10 ppm	5	3	4	1	5	4	4	4	-	96.5	2	90
25 ppm	-	3	-	3	-	4	-	4	-	100.0	-	91
50 ppm	-	3	-	3	-	4	-	4	-	100.0	-	94
100 ppm	-	3	5	5	-	4	5	5	-	72.0	-	-

Contd..

TABLE 4.8: Contd.

Attributes/	Germination % at 144 hrs				Radicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	100.0	9.0	88.0	-	44.5	8.0	40.8	-	18.8	5.3	13.9
1 ppm	4.0	100.0	4.0	94.0	-	14.6	-	33.4	-	6.5	10.6	10.7
5 ppm	-	84.0	9.0	88.0	-	24.2	4.0	21.0	-	8.2	2.6	9.1
10 ppm	4.0	100.0	4.0	94.0	-	11.6	5.0	21.1	-	6.6	2.5	9.6
25 ppm	-	100.0	4.0	94.0	-	7.1	-	8.3	-	4.7	-	4.5
50 ppm	-	100.0	9.0	100.0	-	5.6	-	6.0	-	3.8	-	2.8
100 ppm	-	100.0	14.0	100.0	-	3.0	-	-	-	2.9	-	-

Contd..

TABLE 4.8: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	80.2	-	71.0	-	21.74	6.52	22.51
1 ppm	-	43.3	3.0	72.3	-	16.83	1.36	17.29
5 ppm	-	55.2	27.2	57.3	-	14.74	10.31	12.67
10 ppm	-	47.1	-	55.3	-	12.68	-	12.48
25 ppm	-	18.3	3.8	37.4	-	10.07	1.68	11.43
50 ppm	-	12.2	8.1	38.6	-	4.60	3.24	7.38
100 ppm	-	8.12	5.6	13.5	-	2.79	2.14	3.92

TABLE 4.9: Effect of different concentrations of GA on germination and early seedling growth of *A.monilifer* and *A.rugosus*.

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	1	4	1	-	1	4	1	-	100.0	6	86
1 ppm	4	1	3	1	4	4	4	3	4	96.5	12	92
5 ppm	6	1	1	1	6	2	4	3	-	88.5	12	88
10 ppm	-	1	4	1	-	2	4	3	-	94.0	4	86
25 ppm	-	1	-	1	-	2	-	2	-	100.0	-	76
50 ppm	-	1	4	1	-	2	8	1	-	100.0	14	88
100 ppm	-	1	4	1	-	1	7	2	-	100.0	2	78

Contd..

TABLE 4.9: Contd.

Attributes/	Germination % at 144 hrs				Radicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	100.0	9.0	88.0	-	44.5	8.0	40.8	-	18.8	5.2	13.9
1 ppm	-	100.0	4.0	100.0	2.0	48.7	4.7	54.1	2.0	17.2	5.2	15.9
5 ppm	4	100.0	-	84.0	-	48.2	8.5	58.5	-	17.8	5.7	11.0
10 ppm	-	94.0	-	94.0	-	31.0	-	53.8	-	12.9	-	19.6
25 ppm	-	100.0	-	100.0	-	38.4	-	49.0	-	17.1	-	15.2
50 ppm	-	100.0	-	100.0	-	44.4	2.0	40.0	-	19.6	2.0	16.4
100 ppm	-	100.0	10.0	100.0	-	41.2	-	32.0	-	17.6	-	12.6

Contd..

TABLE 4.9: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	78.0	-	71.2	-	21.7	6.2	22.1
1 ppm	-	70.5	4.0	63.3	-	26.3	3.3	19.2
5 ppm	-	70.0	4.0	62.3	-	20.3	1.2	13.0
10 ppm	-	71.5	3.0	76.3	-	24.8	1.1	18.8
25 ppm	-	66.4	-	47.8	-	18.6	-	15.3
50 ppm	-	76.2	7.2	68.8	-	27.6	4.01	20.4
100 ppm	-	85.3	3.0	75.4	-	26.3	0.8	19.8

ppm = part per millioan

TABLE 4.10: Effect of different concentrations of maleic hydrazide on *A.monilifer* and *A.rugosus* after soaking for 240 hrs.

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	1	4	1	-	1	4	1	-	100.0	6	86
1 ppm	-	1	4	1	-	1	4	1	-	96.5	2	81
5 ppm	4	1	4	1	4	1	5	4	2	100.0	2	96
10 ppm	6	1	7	1	6	1	7	3	-	100.0	-	94
25 ppm	7	1	3	1	7	1	7	2	-	100.0	6	78
50 ppm	3	1	3	1	3	1	3	2	7	96.5	4	94
100 ppm	6	1	5	1	6	1	5	3	-	100.0	-	80

Contd..

TABLE 4.10: Contd.

Attributes/	Germination % at 144 hrs				Radicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	100.0	9.0	88.0	-	44.5	8.0	40.8	-	18.7	5.2	13.8
1 ppm	-	94.0	-	88.0	-	55.4	2.0	31.8	-	19.8	3.8	9.5
5 ppm	4	100.0	14.0	94.0	-	67.3	3.0	51.4	-	12.5	2.0	15.3
10 ppm	4	100.0	-	88.0	-	43.1	-	45.3	-	14.5	-	14.3
25 ppm	-	100.0	9.0	74.0	-	34.2	3.0	35.3	-	10.8	-	9.8
50 ppm	-	94.0	14.0	88.0	-	34.2	3.0	33.8	-	10.2	2.1	9.5
100 ppm	4	100.0	4.0	78.0	-	32.7	3.0	26.8	-	10.5	2.1	7.4

Contd..

TABLE 4.10: Contd.

Attributes/ Treatments	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	78	-	71.0	-	21.7	6.5	22.2
1 ppm	3	72	-	72.3	0.51	18.0	-	14.5
5 ppm	3	73	1.2	57.8	1.2	20.1	2.1	13.6
10 ppm	3	60	3.2	62.8	-	16.3	0.9	15.9
25 ppm	3	38	13.3	37.5	1.0	14.3	3.7	9.4
50 ppm	-	28	26.4	41.6	-	13.8	7.1	12.5
100 ppm	4	27	5.2	36.8	1.0	13.1	2.3	11.3

ppm = part per million

TABLE 4.11: Effect of thiourea solutions on germination and early seedling growth of *A.monilifer* and *A.rugosus* after soaking for 240 hrs.

Attributes/	Initial time lag (days)				Time spread (days)				Germination % at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	1	4	1	-	1	4	1	-	100.0	6	86
1 ppm	-	1	4	1	-	6	4	3	-	100.0	8	84
5 ppm	-	1	-	1	-	4	-	4	-	88.0	-	84
10 ppm	-	1	1	1	-	4	4	2	-	94.0	2	96
25 ppm	-	1	5	1	-	1	5	4	-	94.0	4	85
50 ppm	-	1	4	1	-	1	4	4	-	94.0	16	88
100 ppm	-	1	5	1	-	1	5	4	-	100.0	-	88

Contd..

TABLE 4.11: Contd.

Attributes/	Germination % at 144 hrs				Radicle lenght (mm) at 96 hrs				Fresh weight (mg) at 96 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	100.0	9	88	-	44	8.0	40.1	-	18.8	6.2	13.8
1 ppm	-	94.0	4	88	-	42	5.4	34.5	-	16.2	2.7	12.3
5 ppm	-	84.0	4	84	-	38	-	44.3	-	14.6	-	12.3
10 ppm	-	94.0	-	94	-	38	-	54.7	-	15.1	-	15.3
25 ppm	-	94.0	4	78	-	50	3.8	42.5	-	16.5	1.9	14.4
50 ppm	-	94.09	74	-	38	3.8	42.6	-	-	11.5	2.6	11.3
100 ppm	-	94.0	14	88	-	55	-	53.3	-	12.4	-	14.7

Contd..

TABLE 4.11: Contd.

Attributes/	Radicle length (mm) at 144 hrs				Fresh weight (mg) at 144 hrs			
Treatments	NAM	SAM	NAR	SAR	NAM	SAM	NAR	SAR
Control	-	78.0	-	71.2	-	21.8	6.2	22.1
1 ppm	-	72.3	5.2	66.3	-	20.3	2.5	17.3
5 ppm	-	58.8	7.2	52.8	-	16.9	3.9	14.4
10 ppm	-	77.8	8.3	97.2	-	23.8	5.1	15.1
25 ppm	-	77.2	4.6	68.8	-	22.2	2.6	20.3
50 ppm	-	61.2	3.2	58.4	-	21.9	1.8	14.9
100 ppm	-	69.8	15.0	80.6	-	19.3	7.2	20.7

ppm = part per millioan

RESULTS

Effect of Constant Temperatures

No germination was observed at 0^0C. It started germination at 10^0C and that too after initial time lag of four days of sowing. Enhancement of germination percentage occurred at 20^0C having 89 and 68% in *A.monilifer* and *A.rugosus*, respectively, within 2 and 6 days after soaking. Also the seed showed their radicle within two days in both the species. Radicle length and fresh weight of seeding was maximum in *A. monilifer* in comparison to *A.rugosus*, at 96 and 144 hours. Gradually reduction in germination was observed in both the species at higher temperature (40^0C and 60^0C) at 144 hours (Table 4.1).

Effect of Storage Temperatures

One year of storage at lower temperature (10^0C) showed maximum germination in unscarified seed of *A.monilifer* in comparison to control, 0^0C, 20^0C and 40^0C while maximum germination was observed at 40^0C in *A.rugosus* in unscarified condition. Radicle length and fresh weight followed the trend of germination percentage in both the species (Table 4.2).

Effect of light

Table 4.3 shows that Far red, blue light and dark

resulted maximum germination percentage in *A.rugosus* in comparison to control and scarified seeds of *A.monilifer.* While in *A.monilifer* it showed maximum germination percentage in continuous light, red light and blue light and only. As regards radicle length and fresh weight, *A.monilifer* and *A.rugosus* showed 58.5 mm and 23.04 mg in red light and 75.0 mm and 20.6 mg in dark. respectively. As regards radicle length and fresh weight *A.monilifer* and *A.rugosus* showed 58.5 mm, 23.04 mg and 75.0 mm, 20.6 mg in red light and dark respectively (Table 4.3).

Effect of Mannitol

In different concentrations of Mannitol (Table 4.4) showed decreasing germination percentage from 0.05 M to 0.5 M in comparison to control in both the species of *Alysicarpus* (*A.monilifer* and *A:rugosus*). The radicle length also showed decreasing trend both in *A monilifer* as well as in *A. rugosus* (with stress) except under 0.05 M regime where radicle lenght was slightly higher in *A.monilifer*. There was a gradual reduction of the fresh weight of seedling in both the species with the increasing stress. Here also an enhancement was noticed from 0.05 M to 0.15 M in case of *A.monilifer* and from 0.05 M to 0.2 M in case of *A.rugosus*. The initiation of germination was much delayed in higher concetrations in unscarified *A. monilifer* while in *A.rugosus* it was

delayed in scarified condition. This feature was also observed in the time spread of germination for the seeds of both the species.

Effect of Salt Stress

As in Tables 4.5 and 4.6 the stress caused by NaCl resulted into reduction of germinability after 0.15 M and 0.2 M in *A.monilifer* and *A.rugosus* respectively. Stress caused by 0.3 M and 0.5 M NaCl resulted into complete inhibition of germination in all the species. The adversity of the effect was more pronounced and caused by Na_2SO_4 as no germination was observed after 0.2 M and 0.15 M in *A.monilifer* and *A.rugosus* respectively. Seedling lenght and weight followed the usual trend of reduction with the increasing concentration of Na_2SO_4. The over all adversity was also noticed in the delayed initiation as well as delayed completion of germination.

Effect of pH

The effect of pH showed that there was reduction in germination in the pH-range of 7. while enhancement of germination both in the lower as well as higher pH range was observed in both the species. Unscarified seed of *A.monilifer* germinated in lower pH range while unscarified seed of *A.rugosus* germinated in the pH 7. With respect to radicle lenght and fresh weight higher range of pH was noticed more favourable in both the species (Table 4.7).

Effect of GA

Five percent germination was observed in 1 ppm solution of Gibberellic acid for *A.monilifer*, although maximum germination was observed in case of *A.rugosus* in comparison to control. As regards the fresh weight and radicle length there was slight enhancement with increasing the concentration in both the species (Table 4.8).

Effect of IAA

As in Table 4.9 no significant result of germination percentage in *A.monilifer* was observed while slight enhancement of germination percentage in *A.rugosus* was noticeable with increasing concentration of IAA. Marked reduction of radicle lenght as well as fresh weight was observed with increasing concentration of IAA in unscarified and scarified seeds of both the species in comparison to control.

Effect of MH

Variation in the percentage of germination was not marked under the influence of MH. However, the same was very clear on the attributes like lenght of radicle as well as fresh weight of seedlings. Further the effect was definitely towards retardation of radicle lenght and lowering of fresh weights in both the species in higher concentrations (Table 4.10).

Effect of Thiourea

As in Table 4.11 the increasing concentration and soaking period (upto 240 hours), the germination percentage and mean radicle lenght was more or less increased in both the species while the fresh weight was minimised in *A.monilifer*. It increased in *A.rugosus* in comparison to control.

DISCUSSION

The effect of constant temperature indicated the indentical response for both the species with 10^0C as the minimal temperature of germination. The optimal temperature lay 20^0C for both of them. Further germination gradually decreased from 30^0C onwards. Such behaviour of temperature minima, optima and maxima is in conformity with those of Baskin and Baskin (1974), Sinha (1967), Pandey and Sinha (1978), Pandey and Goel (1983), Singh (1984), Lallan (1988), Sharma (1988).

Generally weedy species show better germination around 30^0C Mumford and Graut (1978). The statement finds support with the present one since both the species displayed seed coat dormancy. Its breakage was thought to be affected by a temperature. Breakage of seed coat dormancy at low (10^0C) and high (30-60^0C) temperature for *A.monilifer* and only high

temperature for *A.rugosus* were in consonance that dormancy is affected by low and high temperature. Further it is worth noting that the two species displayed identical behaviour with regard to early seedling growth being maximum at 20^{0}C. However, *A.rugosus* had comparatively bigger radicles. Lower Storage temperature (0^{0}C) proved better for the maintenance of viability for both the species as is evident from 100% germination of the seed kept at 0^{0}C for one year in comparison to 95% and 100% for the seed kept at room temperature in case of *A.monilifer* and *A.rugosus* respectively. In this context the better adapted species appear to loose the threshold of dormancy at the 10^{0}C temperature. Such response to varying storage temperatures has also been observed by Narty (1978). This feature was also evident in having one day of initial time lag in both the species before the radicles could come out. In the similar way the seedling growth also appeared affected by higher storage temperature at which the better species were with shorter radicles. In this context it is worth noting that lower (0^{0}C) temperature helped in maintenance of dormancy and viability in both the species. These results are in accordance with the observation of Pandey and Ojha (1981), Pandey and Goel (1983), Ahmad (1985), Ellis and Roberts (1979) who have attributed that deteriorative processes during storage are accelerated at higher temperature and that lower temperature resisted them. The explanations might be applicable

here as well. This feature is in line with the observation of data on the effect of light which indicated no significant effect in both the species. Even the effect of red radiation may not be marked in *A.rugosus*. However, far-red caused some reduction in *A.monilifer*. Many workers (Valio and July, 1979; Widell, 1983) have reported significant effect of red and far red conditions caused by phytochrome balance. According to Nwoke (1962) the events occurring during dark incubation of light sensitive seeds probably involve a biochemical synthesis of factors rapidly utilised by light to stimulate seed germination and that in terms of phytochrome action they are well correlated with Pr. and Pfr. balance. In this context both the species probably had proper balance of Pr. and Pfr. inherently and hence behaved as non photo-blastic seeds. With regard to radicle length, the differential behaviour of *A.monilifer* with longer radicles than those of *A.rugosus* has been observed. The stress of Mannitol was not beneficial for *A.monilifer*. However, the percentage of germination lowered to 45% in *A.rugosus* under 0.5 M solution in comparison to control. The stress caused by NaCl resulted into more severe effect with increasing concentration, on 0.25 M and onwards and the complete inhibition of germination in both the species. In this way the results are in conformity with that of Mechal (1970). Further the adverse effect was more vivid in the elogation of radicles and fresh weights of the seedlings. Similarly

Na_2SO_4 had most severe effect with regard to total germination as well as the early seedling growth of the two species. The effect appeared to be more pronounced in *A.rugosus* and hence *A.monilifer* showed more tolerance to such stress. Investigators including Williams and Unger (1972); Gomes *et al.* (1983) have also found similar results. It is also of significance that the initial time lag for the emergence of radicle was delayed probably because of delayed imbibition of water (Prisco and Viera, 1976). Heikal and Saddad (1982) have also observed effect on seedling growth because of the retarded water uptake and salinity stress. The various biochemical disturbances observed are :

(a) L-amylase activity inhibited (Dube, 1982).

(b) Soluble carbohydrate level reduced and free amino acids increased (Kole and Gupta, 1982).

(c) Hydrolysis and translocation of food reserves to embryoinhibited (Kabir and Polzakoff. Mayber. 1975).

(d) de novo synthesis of enzymes in cotyledons delayed (Gomes *et al.*, 1983).

(e) Reduction of endogenous Cytokinins (Bozcuk. 1981).

In all probability these would have been the causal factors in the present case as well.

The data on the effect of pH indicated more adverse effect of alkaline pH than the acidic one in both the species. Garg and Garg (1981) and Lodhi (1982) have also fund similar adverse effect of alkaline pH on germination.

The effect of growth hormones have been variously observed. However, it is a point of much concern that contradictory results are plenty with regard to their promotory, inhibitory or having no effect. In view of these facts in the present case of the three growth substances used, it is worth noting that lower concentration did cause to certain extent, enhancing effect in both the species. Further, the higher concentrations on the other hand had either inhibitory effect or no effect. With regard to IAA, no effect could be discernible in *A.monilifer* on the other hand slight enhancement was noticed in the other species. Germination was hastened along with the elongation of radicle and fresh weight upto 25 ppm. These results are in line with the observation of Kumar and Agrawal (1979), Mayer and Poljakoff-Mayber (1982), Singh (1984), Ahmad (1985) and Sharma and Govind (1987). In neither of the species, GA had any significant effect. The results are in consonance with those of Blackely *et al.* (1972), Goyal and Baijal (1980) and Singh (1984).

Maleic hydrazide is a known retarder, but in the present case no significant reduction in the percentage of germination could

be marked. However, it retarded the radicle growth in both the species. Such a result is in line with those of Katyayani *et al.* (1980), who have also observed reduced radicle lenght. The two species differed with regard to fresh weights in which *A.monilifer* displayed higher weights. Thiourea caused no significant effect except that there was a faint effect in the breakage of dormancy in both the species, although *A.rugosus* showed more response. Mayer and Polzakoff-Mayher (1982) have also reported scarifying quality of thiourea to certain extent. From the present finding H_2SO_4 treatment for 15 and 10 minutes were found optimal for *A.monilifer* and *A.rugosus* respectively indicating harder coat in former. Timson (1965) has also reported scarifying effect of H_2SO_4. From observation on germination and moisture percentage it is evident that immature seeds had ripe embryos and that with maturity coat dormancy was developed in both the species. These results confirmed the finding of Pandey and Sinha (1978), Ahmad (1985).

CHAPTER - V

BIOMASS, PRODUCTIVITY AND ENERGY DYNAMICS

BIOMASS, PRODUCTIVITY AND ENERGY DYNAMICS

INTRODUCTION

Standing crop biomass is the amount of organic material present in a community or population at a given time. It is generally expressed in terms of dry weight and occasionally as ash free dry weight. The production is the weight or biomass of organic matter assimilated by an organism or community over a given period of time. The primary production is the production of organic matter by photosynthesis and secondary production is the subsequent conversion of that organic matter by heterotrophic organisms. Gross primary production (GPP) is the total photosynthesis or total assimilation and this includes the amount of organic matter used up in respiration during the measurement period. Net primary production (NPP) is the rate increased of biomass. The primary production in an ecosystem is the production of organic matter as a result of photosynthetic activity of green plants in presence of sunlight and with the help of water, CO_2 and chlorophyll. The basic reaction being-

$$6CO_2 + 12\ H_2O \xrightarrow[\text{chlorophyll}]{\text{light}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Energy is the basic force responsible for running the machine of life. In fact energy is the capacity to do work and all

living things must work. There is an increasing tendency of using energy estimation in analysing the level of production in various ecosystem rather than only the biomass because it gives a finer picture of the system productivity. It is well known that energy which drives the ecosystem on the planet earth comes from the sun. At the outer limits of our atmosphere, 1.49 gram calories of solar energy per square centimeter are received per minute, of which 35 percent is reflected and 17.5 per cent is absorbed by atmosphere and cloud and 47.5 per cent reaches the earth's surface. But there is wide local variation in solar radiation input to the earth's surface depending upon the cloud cover, clearity of the atmosphere and other factors.

Ecological energetics of many agricultural crops have been studied by various workers (Long, 1934; Lieth, 1968; Murata *et al.*, 1968; Misra *et al.*, 1970; Singh, 1971; Twaki, 1974; Ryszkowski, 1975; Singh, 1975; Dua and Sharma, 1976; Loucks, 1977; Dhingra, 1978; Kumar, 1984; Nath, 1990). The present study deals with biomass, productivity, calorific concentration and energy structure of two herbaceous species i.e. *Alysicarpus monilifer* and *A.rugosus* growing in prevailing climatic conditions of Orai.

MATERIALS AND METHODS

Standing Crop Biomass

The sampling of two species of *Alysicarpus* was done after 15 days of the emergence of seedling. Samples were taken at the interval of 15 days of two successive sampling. At each sampling occasion five plants were selected randomly and were dug out individually upto a depth of 30 cm. Monoliths of the sampled plants were washed carefully to remove soil from the root system. Sampled plants were cut to separate their component part. Plants were dried in oven at 80^0C for 48 hours. The dried samples were weighed. The average dry weight of five plants were estimated and biomass was expressed in g/plant. The standard deviation was calculated for all the mean value.

Net Primary Productivity (NPP)

It was calculated by using the following formula :

$$\text{NPP (g/plant/day)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where W_1 and W_2 are standing crop biomass at time t_1 and t_2, respectively.

Calorific Value

The calorific value of different component of *A.monilifer* and *A.rugosus* were estimated from samples collected at

the intervals of 15 days of the germination (2002-2003).

(a) Sampling of Plant Materials

Sampling of *A.monilifer* and *A.rugosus* was sorted in stem, leaf, flower, pod and root. The sampling was made at the interval of 15 days from July 2002 to October 2002.

(b) Drying

The samples were dried for 48 hours at 80^{0}C until the weight of samples were constant.

(c) Milling and Pelleting

The dried materials were powdered and stored in plastic bags closed and labelled with sample number. Pellets of powdered samples were prepared by compressing it in a pellet press. In order to avoid incomplete combustion the weight of pellets were kept below one gram varying between 0.6 to 0.9 g. Dry weight of pellets were taken before the combustion of each sample.

(d) Estimation of Calorific Values

Calorific values of plant samples were estimated by Parr Oxygen Bomb Calorimeter. Weighed pellets were placed in the ignition cup of the bomb with the help of nickel chromium fuse wire. The whole device filled with oxygen at 13-15 atmospheric pressure was immersed in a bucket filled with water. The volume of

water taken inside the water bucket was kept constant at 1300 ml through but in all the combustions. The temperature of water was carefully recorded initially and after the combustion, the difference between two readings was used for calculation of the calorific values.

(e) Fuse Wire Correction

Each combustion was initiated through an electric current which resulted into energizing the nickel chromium fuse wire and igniting the sample. The heat released was proportionate to the lenghts of wire between the electrodes. The correction factor used for fuse were is 2.3 cal/cm (Parr Inst. Co. Mannual 130, 1968). Ten cm of fuse wire was used in all estimation and hence a correction of 23 calories was made.

(f) Acid Correction

Another, minor source of error is the formation of acids primarily nitric and sulphuric ones following combustion of organic compound under pressure. The sulphur correction is made on the basic assumption that this element is completely converted into H_2SO_4 with a higher release of heat than would occur if it was simply oxidized to SO_2, as would occur at normal atmospheric pressure. Formation of nitric acid also occurs under conditions prevailing in a bomb calorimeter.

An acid correction was estimated by assuming that the acid was entirely HNO_3, as amount of sulphur in plant material was insignificant. About 5 ml of water was poured into the bottom of the bomb before combustion and later on after burning of pellet this solution was titrated against 0.07 N sodium carbonate using 1-2 drops of methyl red as an indicator. At this condition normally 1 ml titrate of sodium carbonate is equivalent to 1 calory. The correction of acid was substracted from the calculated calorific value.

The gross heat of combustion on the calorific concentration per gram of the plant material on dry weight basis and ash free weight basis was calculated as follows (Parr Inst. Co. Mannual 130; 1968).

Gross heat of combustion, $Hg = \frac{tw - e_1 - e_2 - e_3}{m}$ cal/g

where t = rise in temperature (0^0C)

w = water value of the calorimeter (cal)

e_1 = acid correction of HNO_3 (cal)

e_2 = acid correction of H_2SO_4 (cal)

e_3 = fuse wire correction (cal)

m = weight of the pellet (g)

Acid correction of H_2SO_4 (e_2) has not been estimated in the present study.

(g) Water Value of the Calorimeter

The calibration of the calorimeter was done using benzoic acid. The calibration was made to ensure that subsequent calculations arrive at the number of calories necessary to rise the temperature of water bath by 10^{0}C. This is called water value of the system. The water value of the calorimeter was calculated by the following formula (Parr Inst. Co. Mannual 130, 1968).

$$W = \frac{Hm + e_1 + e_3}{t} \text{ cal}/^0C$$

Where W = Water value of the calorimeter

H = Heat of combustion of benzoic acid (6318 cal/g)

m = Weight of benzoic and pellet (g)

e_1 = Acid correction of HNO_3 (cal)

e_3 = Fuse wire correction (cal)

t = Rise in temperature (^{0}C)

The estimated value of w (present case) = 1959.92 cal/^{0}C

B. Energy Structure

The energy structure in the standing crop was calculated from multiplication of biomass and energy per gram value.

RESULTS

Standing Crop Biomass

The standing crop biomass of *Alysicarbus monilifer* and *Alysicapus rugosus* was studied and the biomass values are shown in Tables 5.1 and 5.2.

Alysicarpus monilifer

The mean total biomass at 15 days of growth was found to be 0.0539 g/plant which increased gradually upto 2.3308 g/plant at 105 days. The biomass of different part of *A.rugosus* is shown in Table 5.2.

Per cent Contribution of Plant Parts

The per cent contribution of each part i.e. stem, leaf, flower, root to the total plant biomass of *A.monilifer* and *A.rugosus* has been presented in Table 5.3.

Mean and Current Increments in Biomass

The mean and current increments to total plant biomass has been studied in *A.monilifer* and *A.rugosus*. The results have been tabulated in Table 5.4.

Net Primary Productivity

Net primary productivity of different part of

TABLE 5.1: Mean standing crop biomass (g/plant) of *Alysicarpus monilifer.*

Age (days)	Shoot				Root	Total Plant biomass
	Stem	Leaf	Flower	Total		
15	0.0113 ±0.0015	0.0363 ±0.0068	-	0.0476 ±0.0071	0.0063 ±0.0012	0.0539 ±0.0081
30	0.0256 ±0.0033	0.0705 ±0.0104	-	0.0961 ±0.0118	0.0142 ±0.0022	0.1103 ±0.0197
45	0.2549 ±0.0381	0.3156 ±0.0662	-	0.5705 ±0.0913	0.0986 ±0.0166	0.6691 ±0.0868
60	0.4311 ±0.0645	0.5336 ±0.0906	-	0.9647 ±0.1632	0.1638 ±0.0265	1.1285 ±0.1578
75	0.6128 ±0.0734	0.7338 ±0.1393	0.3612 ±0.0504	1.7078 ±0.1012	0.2395 ±0.0406	1.9473 ±0.3311
90	0.6083 ±0.0668	0.7184 ±0.1072	0.4563 ±0.0501	1.7830 ±0.3121	0.2283 ±0.0387	2.0113 ±0.0361
105	0.5982 ±0.0956	0.7016 0.0772	0.8311 ±0.1413	2.1309 ±0.2342	0.1999 ±0.0298	2.3308 ±0.4193

TABLE 5.2: Mean standing crop biomass (g/plant) of *Alysicarpus rugosus*.

Age (days)	Shoot				Root	Total Plant biomass
	Stem	Leaf	Flower	Total		
15	0.0084 ±0.0017	0.0289 ±0.0052	-	0.0373 ±0.0056	0.0053 ±0.0012	0.0426 ±0.0067
30	0.0193 ±0.0037	0.0513 ±0.0076	-	0.0706 ±0.0134	0.0083 ±0.0013	0.0789 ±0.0148
45	0.2001 ±0.0300	0.2888 ±0.0462	-	0.4889 ±0.0733	0.0891 ±0.0133	0.5780 ±0.0877
60	0.3133 ±0.0469	0.4863 ±0.0632	-	0.7996 ±0.0959	0.0999 ±0.0089	0.8995 ±0.1049
75	0.5177 ±0.0766	0.6186 ±0.979	0.2963 ±0.0325	1.4326 ±0.2721	0.1872 ±0.0214	1.6198 ±0.2936
90	0.5001 ±0.0551	0.5913 ±0.0651	0.3818 ±0.0341	1.4732 ±0.2209	0.1781 ±0.0230	1.6513 ±0.1815
105	0.4978 ±0.0447	0.5798 ±0.0694	0.7677 ±0.0718	1.8453 ±0.2029	0.1679 ±0.0251	2.0132 ±0.3010

TABLE 5.3: Per cent contribution of plant parts to total plant biomass of *Alysicarpus monilifer* and *Alysicarpus rugosus*.

Age (days)	*A. Monilifer*				*A.rugosus*			
	Stem	Leaf	Flower	Root	Stem	Leaf	Flower	Root
15	20.96	67.34	-	11.69	19.72	67.87	-	12.44
30	23.21	63.92	-	12.87	24.46	65.02	-	10.52
45	38.10	47.17	-	14.74	34.62	49.97	-	15.42
60	38.20	47.28	-	14.51	34.83	54.06	-	11.11
75	31.47	37.68	18.49	12.30	31.96	38.19	18.29	11.56
90	30.24	35.72	22.69	11.35	30.29	35.81	23.12	10.79
105	25.67	30.10	35.65	8.58	24.73	28.80	38.13	8.34

TABLE 5.4: Total plant biomass, mean and current increment in biomass of *Alysicarpus monilifer* and *Alysicarpus rugosus*.

Age	Total biomass (g/plant)		Mean increment in biomass (g/plant/day)		Current increment in biomass (g/plant/ day)	
	A. monilifer	*A. rugosus*	*A.monilifer*	*A.rugosus*	*A.monilifer*	*A.rugosus*
15	0.0539	0.0426	0.0035	0.0028	-	-
30	0.1103	0.0789	0.0036	0.0026	0.0037	0.0024
45	0.6691	0.5780	0.0148	0.0128	0.0372	0.0332
60	1.1285	0.8995	0.0188	0.0149	0.0306	0.0214
75	1.9473	1.6198	0.0259	0.0215	0.0545	0.0480
90	2.0113	1.6513	0.0223	0.0183	0.0043	0.0021
105	2.3308	2.0132	0.0221	0.0191	0.0213	0.0241

Alysicarpus monilifer and *Alysicarpus rugosus* has been presented in Table 5.5. Net primary productivity of shoot in *A.monilifer* with an increasing trend ranged from 0.0031 g/plant/day to 0.0495 g/plant/day between 15 and 75 days. Later on it has decreased to 0.005 g/plant/day at 90 days of growth. Net primary productivity of shoot in *A.rugosus* ranged from 0.0025 g/plant/day to 0.422 g/plant/day between 15 to 75 days.

Net primary productivity of both *A.monilifer* and *A.rugosus* has not definite trend. It was negative production at the age of 90 and 105 days of the plant in both the species of *Alysicarpus*.

Calorific Concentration

Calorific concentration in the different components of *Alysicarpus monilifer* and *Alysicarpus rugosus* has been tabulated in Table 5.6. The trends of calorific concentration were found to be similar in the both species of *Alysicarpus*.

Calorific concentration in stem increased from 3286 cal/g to 4587 cal/g in *A.monilifer*, 3088 cal/g to 4381 cal/g in *A.rugosus* between 15 and 75 days. Later on it had decreased to 4389 cal/g in *A.monilifer* and 4191 cal/g in *A.rugosus* at 105 days of growth.

Calorific concentration in leaf was found to be increasing in two species between 15 days and 75 days i.e. 3548 cal

TABLE 5.5: Mean net primary productivity (g/plant/day) of *Alysicarpus monilifer* and *Alysicarpus rugosus.*

Age	*A. monilifer*			*A. rugosus*		
(days)	Shoot	Root	Total	Shoot	Root	Total
15	0.0031	0.0004	0.0035	0.0025	0.0003	0.0028
30	0.0032	0.0005	0.0037	0.0022	0.0002	0.0024
45	0.0316	0.0056	0.0371	0.0278	0.0053	0.0331
60	0.0262	0.0043	0.0305	0.0207	0.0007	0.0214
75	0.0495	0.0050	0.0545	0.0422	0.0058	0.0480
90	0.0050	-0.0007	0.0043	0.0027	-0.0006	0.0021
105	0.0231	-0.0018	0.0213	0.0248	-0.0006	0.0242

TABLE 5.6: Mean caloric value (cal/g) weight of different component of of *Alysicarpus monilifer* and *Alysicarpus rugosus*.

Age	*A. monilifer*				*A. rugosus*			
(days)	Stem	Leaf	Flower	Root	Stem	Leaf	Flower	Root
15	3286	3548	-	3175	3088	3351	-	2977
30	3414	3708	-	3259	3216	3511	-	30/61
45	3670	3905	-	3347	3471	3709	-	3149
60	3975	4308	-	3469	3777	4112	-	3271
75	4587	4725	4917	3526	4157	4529	4717	3328
90	4544	4678	5230	3409	4381	4388	5040	3210
105	4389	4478	5463	3319	4191	4246	5257	3012

g to 4725 cal/g (*A.monilifer*) and3351 cal/g to 4529 cal/g (*A.rugosus*). Later on it had decreased to 4478 cal/g (*A.monilifer*) and 4246 cal/g (*A.rugosus*) at 105 days.

Calorific concentration in flower increased between 75 days and 105 days of growth in two species from 4917 cal/g to 5463 cal/g (*A.monilifer*) and 4717 cal/g to 5257 cal/g (*A.rugosus*).

Calorific concentration of root increased between 15 days and 75 days. Later on it had decreased at the age of 105 days of growth.

Energy Structure

Data of energy structure have been presented in Table 5.7 and Fig. 5.1 and Fig. 5.2 for *A.monilifer* and *A.rugosus*. It has bee expressed in Kcal/plant.

Energy structure in the stem increased from 0.03 Kcal/plant to 2.764 Kcal/plant between 15 and 90 days in *A.monilifer*, 0.025 cal/plant to 2.086 cal/plant between 15 days and 105 days in *A.rugosus*. Energy structure in leaf of *A.monilifer* and *A.rugosus* shows the same trend like stem. Flower had increasing trend from 75 days to 105 days. It was not a definite trend of energy structure in root of both the species.

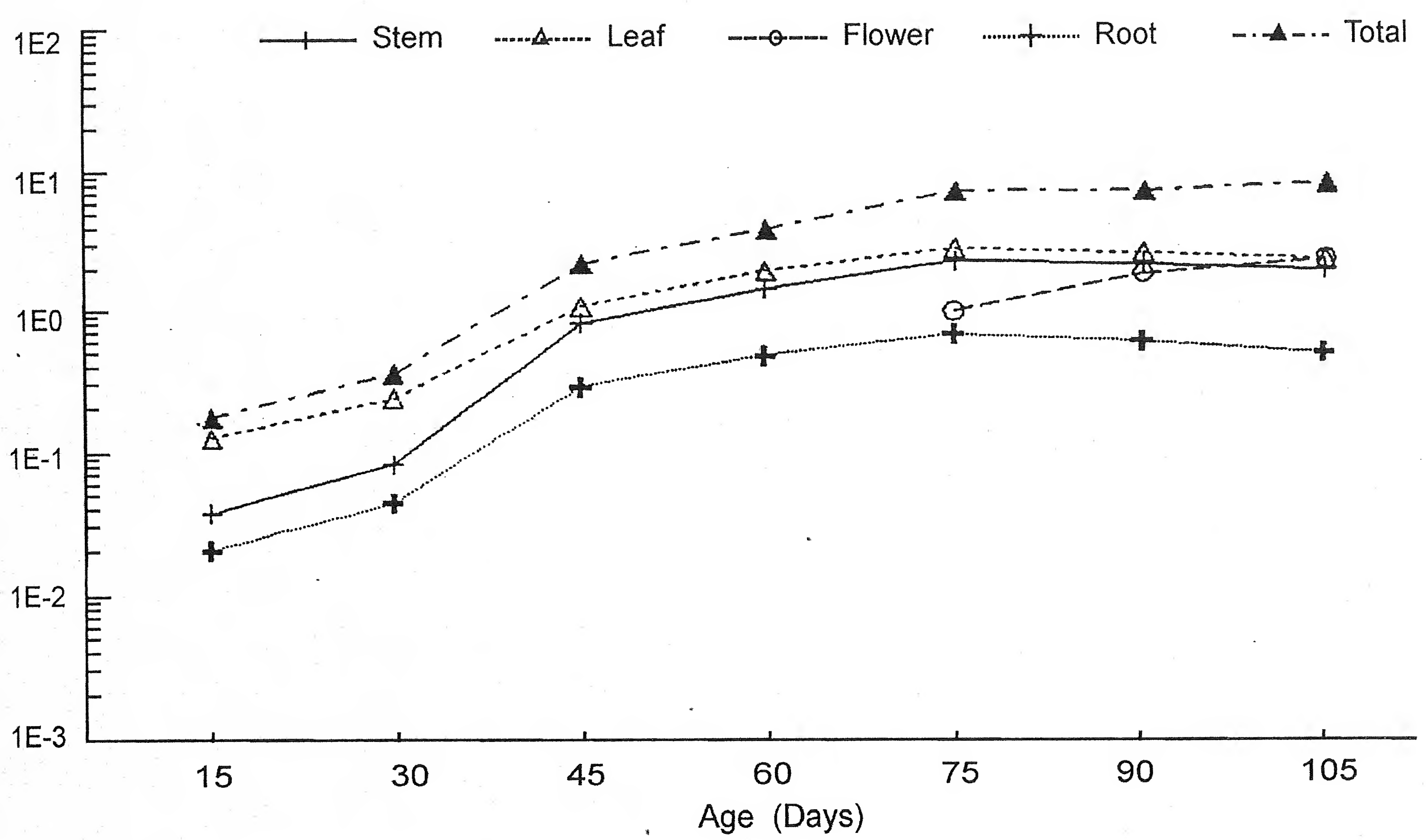

Fig.5.1: Mean standing crop of energy (K cal/plant) of different component of *A.monilifer*

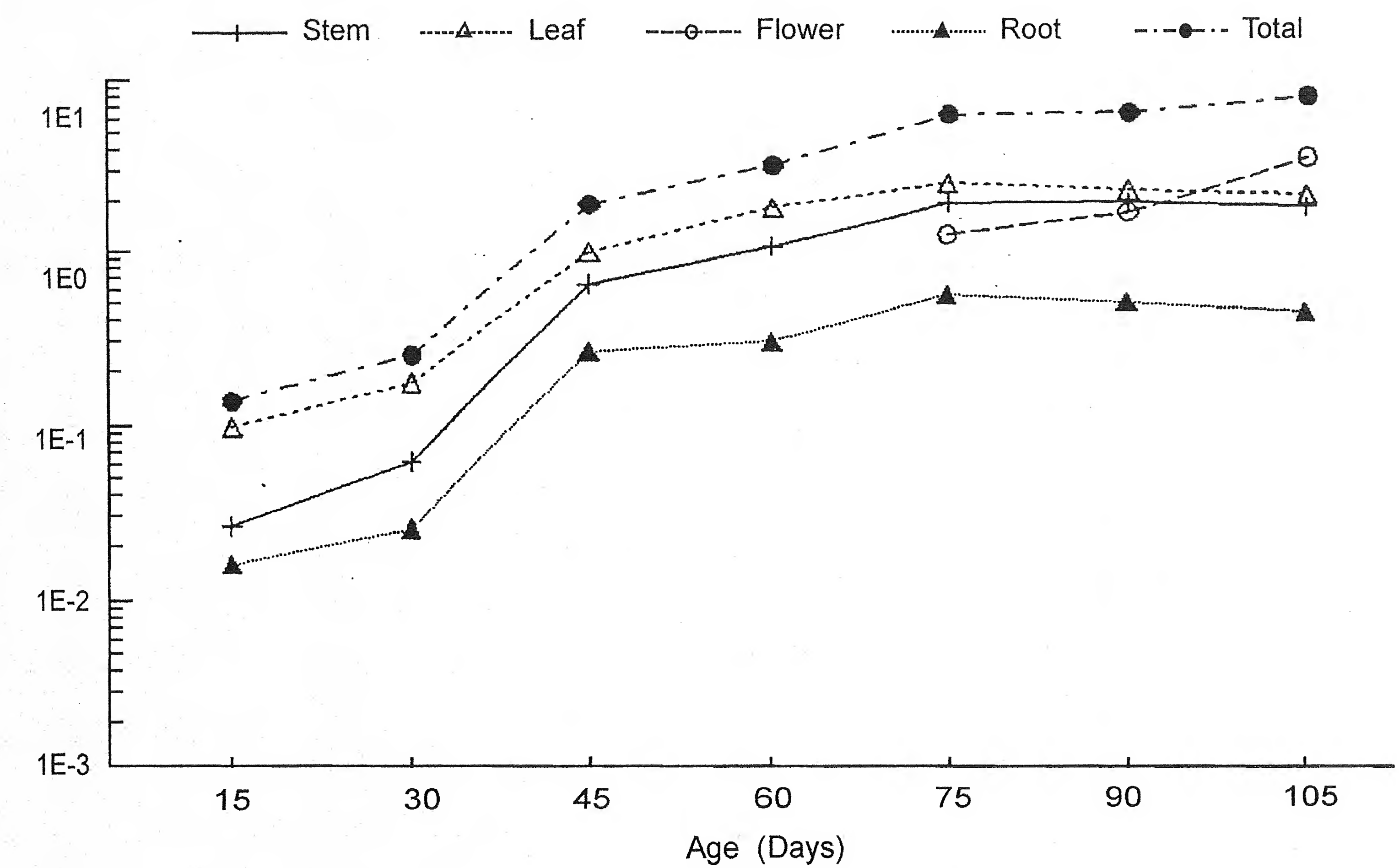

Fig.5.2: Mean standing crop of energy (K cal/plant) of different component of *A.rugosus*

TABLE 5.7: Mean standing crop of energy (Kcal/plant) of different component of *Alysicarpus monilifer* and *Alysicarpus rugosus*.

Age	*A. monilifer*					*A. rugosus*				
(days)	Stem	Leaf	Flower	Root	Total	Stem	Leaf	Flower	Root	Total
15	0.037	0.128	-	0.020	0.180	0.025	0.096	-	0.015	0.136
30	0.087	0.261	-	0.046	0.390	0.062	0.180	-	0.025	0.260
45	0.935	1.232	-	0.330	2.497	0.694	1.071	-	0.280	2.040
60	1.714	2.298	-	0.568	4.580	1.183	1.999	-	0.326	3.500
75	2.811	3.467	1.776	0.844	8.890	2.152	2.802	1.397	0.623	6.970
90	2.764	3.360	2.386	0.778	9.280	2.191	2.594	1.920	0.571	7.270
105	2.625	3.141	4.540	0.663	10.960	2.086	2.462	4.035	0.505	9.080

DISCUSSION

Biomass and Primary Productivity

The biomass and productivity of *A.monilifer* and *A.rugosus* studied in the present investigation varied with the age of the plant. Net photosynthetic rate as assessed by harvest method are maximum between 15 to 30 days after the emergence of the seedling. Obviously the young fully expanded leaves and the green shoot photosynthesize most vigorously and add maximum amount of dry matter to the plant body. In an annual plant grown under constant environmental condition the net assimilation rate becomes maximum soon after the seedling phase (William, 1946). Shiroya *et al.* (1961) exposed various leaves of tobacco to $^{14}CO_2$ and found the largest amounts of radioactive carbon accumulated in the newly expanded leaves.

After the flowering stage rate of net photosynthesis and dry matter production decline gradually. Smillie (1962) found that after pea leaves are fully expanded, their photosynthetic and respiratory rates start to decline. With increasing age, a bean leaf becomes progressively less effective as an assimilatory organ. It has been suggested that the deterioration of anabolic activities contributes to the senescence of leaf (Das and Leo Pold, 1964). This deterioration may occur in the chloroplast for the chloroplast preparations from leaves of increasing age show

decreasing capacity for the photolysis of water (Clendenning and Gorham, 1950; Miller, 1960). Fuess and Tesar (1968) observed that net photosynthetic activity of alfalfa leaves decreased with age. 3 week old leaves being seven times less active than 5 days old leaves. A relation between intensity of photosynthesis and chlorophyll content as influenced by the age of the leaf in *Nicotiana sanderae* has been shown by Sestak and Catsky (1962). Assessment of the productivity of *A.monilifer* and *A.rugosus* have also shown a positive correlation between net photosynthetic rate and the chlorophyll content of the leaves, both of which decline gradually as the age advances. The maximum rate of dry matter accumulation is obtained in the early growth period when the chlorophyll content of the young leaves is the highest.

It has been experimentally shown by several workers in various annual species that the flowering and fruiting bring about the senescene of the plant, associated with the decline in their photosynthetic capacity (Murneek, 1926; Singh and Lal, 1935; Molisch, 1938; Leopld, 1964; Johanstone, 1969). Possibly decrease in the photosynthetic rate in *A.monilifer* and *A.rugosus* at flowering and fruiting phases can also be attributed to the onset of senescene in the plant. At fruiting stage there is a very little rise in the net photosynthetic rate which is perhaps due to the photosynthetic activity of the developing green pods. Dwivedi (1970) has shown

that the production efficiency of young wheat ear is about two times greater than the older leaves. As assimilative power deteriorate so also does the repiratory ability in *A.monilifer* and *A.rugosus*. The subsiding respiratory ability of leaves with age has been observed by Mac Donald and De Kock (1958).

Energy Dynamics

The energy value obtained at different stages of life cycle of *A.monilifer* and *A.rugosus* vary with the age. The calorific value in *A.monilifer* and *A.rugosus* were maximum at the flowering stage but in the successive stage of flowering and fruiting the stored material is utilized to a considerable extent in the formation of reproductive potential and thus the energy value decrease consequently.

The caloric value of the plant material depends upon the quality and quantity of food reserve in its. The energy content of a plant is governed by its genetic constitution, stage in the life history and nutritive status, especially the fat content. Fat is the richest source of energy and upon complete combustion yield an average of 5900 cal/g whereas carbohydrates and proteins yield only 4100cal/g and 4700 cal/g, respectively (Fruton and Simmons, 1953). Therefore, a slight variation in the percentage of fat would cause a remarkable change in the energy value of the plant materials. Storage and conversions of different organic compounds in different

plant parts are strongly related to climatic factors and life cycle stage. Therefore, the environmental conditions play an important role in influencing these factors. Long (1934) has reported that the caloric value varies with light intensity, length of the day, amount of the nutrient and type of soil in which plants grow.

It has been observed that the energy concentration in vegetative part of *A.monilifer* and *A.rugosus* increased with age till flowering. Later on it has decreased. The energy concentration in flower was found to be increasing right from its initiation to its maturity. This trend of variation of energy concentration in different plant parts is attributed to changing ratio of fat, carbohydrate and protein in the dry matter. Fat is the richest source of energy. Fat and oil enriched organs thus may exceed 5 Kcal/g dry weight calorific value (Lieth, 1968). The energy content and its distribution pattern in plant is governed by its genetic ability, development stages of plants and environmental complex.

Energy accumulation pattern of *A.monilifer* and *A.rugosus* reveals that the accumulation capacity of different organs in *A.monilifer* and *A.rugosus* changes with developmental stages. Obviously the age of the plant affects the dry matter production which may finally determine the energy storage in plant parts at various stages of growth (Singh, 1975; Nath. 1990).

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CHAPTER - VI

EFFECT OF SHADING ON GROWTH

EFFECT OF SHADING ON GROWTH

INTRODUCTION

Briggs *et al.* (1920) can be taken as pioneers for analysing the effect of such environmental factor on growth and yield of plants. Since then many workers have contributed towards in understanding on the role of light on the growth performance of cultivated as well as wild plants. Notable among them are Watson *et al.* (1963), Hodgson (1967), Loach (1970), Rajan *et al.* (1981). Hurd and Thorneley (1974), Warrington *et al.* (1978), Pandey and Sinha (1979), Sharma (1988), Lallan (1988), Packhan and Willis (1962), Corre (1983), Goel (1983), Hunt *et al.* (1984). Muthuchelian *et al.* (1989-99). Sosa *et al.* (1998), Park *et al.* (1996), Islam *et al.* (1999), Lorenzo *et al.* (2003). Among the three distinct components of light intensity, duration and spectral composition, the former has long been known to affect the productivity of the plants. The effect of shading was intensively studied by Evans and Hughes (1961) while working on *Impatiens parvifflora.* They found specific relationship among various growth attributes, which could be utilized as a good correlative yardstick for measuring the role of environmental factors. Loach (1970) measured the shade tolerance of various trees. Pandey and Sinha (1977) compared the adaptability of two closely allied species of *Crotalaria*

under different light climates. In the recent past intracting effect of light with the other factors of environment has also attracted the attention of investigators (Packham and Willis. 1982; Neves *el al.*, 1982; Yamasaki and Jjike, 1982; Hunt *et al.*, 1984), who have noted that upto three hundred calorie (cm^2/day) of radiation have an enhancing effect on the growth. They are standardised the technique of studying the effect of such factors by way of growth analysis in which various parameters including the relative growth rate (RGR), net assimilation rate (NAR), leaf area ratio (LAR) etc. have been worked out. The RGR was found to be adversely affected by decreasing light intensities. On the other hand the LAR is known to increase with decreasing light, of course, within a limited range. In the similar way Watson *et al.* (1963) and several other workers have found positive relationship of NAR with light. Thus the role of NAR and LAR appeared in different directions for maintenance of RGR.

The two legumes namely *A.monilifer* and *A.rugosus* occur as the khariph plant growing intermingled with the tall grasses. Initially they have to face the shading of tall grasses plants. In the present chapter attempt has been made to compare their adaptability in the three different light intensities namely 100% (SI), 90% (SII) and 70% (SIII) by making tents within the specially designed iron frame.

MATERIALS AND METHODS

Culture Experiments

Four culture experiments, earthen pots of 20 cm height and of 15 and 8 cm diameter at the inside top and bottom respectively, were used. Pots were filled with a mixture of powdered field soils, sandy soil and farmyard manure (in the ration 5:2:3 v/v). All pots had equal amount of soil in them. Seeds of the two species of *Alysicarpus* were sown in pots on 10th of July, 2002, for effect of shading, soil moisture, and intraspecific competition. After a week of sowing seedling were thinned out to have only one in each pot except in density treatments. Pots were watered time to time to maintain their field capacity from the dates of sowing till the final harvest.

Treatment for different culture experiments were started after just one week of thinning. Seeds for varying sowing dates were sown on 10th July, 2002.

Shading

White Muslin cloth and Mosquito net were used to cover iron frame (2 m x 1, x 1.5 m) made cages under which artificial shading on plants was created. Three light regimes (measured with the help of luxmeter) were :

SI Full light under natural day condition

SII Light under netted cloth cover (90%)

SIII Diffused light under muslin cloth (70%)

Growth Analysis

The following derived growth parameters, considered useful for comparing the two species, were used in the present investigation as per Evans (1972).

I. Relative growth rate (RGR) :

$$\frac{\text{Loge } W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W_1 and W_2 and total plant dry weights at time t_1 and t_2 respectively and $t_2 - t_1$ was 7 days (One week).

II. Net assimilation rate (NAR)

$$\frac{(W_2 - W_1)(\text{Log}_e L_2 - L_1)}{(t_2 - t_1)(L_2 - L_1)}$$

Where,

L_1 and L_2 were total leaf areas and W_1 and W_2 total plant dry weights at time t_1 and t_2 respectively. As weekly harvest were taken for the calculation of RGR and NAR was not divided by two and was left as such.

III. Leaf area ratio (LAR) :

$$\frac{\text{Total leaf area}}{\text{Total plant dry weight}}$$

IV. Leaf weight ratio (LWR) :

$$\frac{\text{Total leaf dry weight}}{\text{Total Plant dry weight}}$$

V. Specific leaf area (SLA) :

$$\frac{\text{Total leaf area}}{\text{Total leaf dry weight}}$$

VI. Shoot/Root ratio (S/R ratio) :

$$\frac{\text{Total dry weight of shoot}}{\text{Total dry weight of root}}$$

Data on dry weight accumulation, leaf area increases, RGR, NAR, LAR were analysed statistically for significance test by analysis of variance according to Bailoy (1959).

Chlorophyll Content

Chlorophyll was extracted from fresh leaves (discarding midrib) with 80% acetone and optical densities were measured at 654 and 663 nm and chlorophyll a, chlorophyll b and total chlorophyll per gram tissue was calculated according to Witham *et al.* (1971).

Calculation of F Statistic

In order to get certain positive results with few calculations and with greater efficiency, means of multi samples were compared using a different test. Such a test involving many samples is known as analysis of variance. The analysis was directed to (1) variations between the treatments which were ordinarily shown in vertical columns of the table (2) variations between the two species (3) variations between harvests which were shown in horizontal columns of the table (4) intractions in between sp x treatment (5) intractions in between treatment x harvest (6) intractions in between harvest x species (7) variation due to error.

Procedure for Calculation of F Statistics

1. Separately arranged the data of two different species (*A.monilifer* and *A.rugosus*) in a tabular form showing treatments in vertical columns and replicates in horizontal columns.

2. Summed up all observations by vertical columns and all observations by horizontal columns in two separate tables.

3. Total summed up value of vertical column and horizontal column will be the same. Grand total of one species was 'a' and other species was 'b'.

4. Now each sample of one species were summed up with corresponding sample of another species. In this way third table were prepared.

5. In the third table also samples of vertical column and horizontal columns were summed up which gives up $t_1 + t_2 + ... + t_n$ of horizontal columns. Total treatments as well as of harvests are the same which is the grand total. For convenience a chart is being produced.

6. Cf were calculated dividing the grand total square by total no. of samples.

   hence Cf $=(Gr)^2/n$

7. Total sum of square = $(S^2 + S^2 + ...S^2_{36})$ - Cf = E of all samples$)^2$ - Cf.

RESULTS

The results have been presented in Tables 6.1 to 6.8.

As seen in Table 6.1 - 8 and number of branches per plant (Fig. 6.2) varied from 16 in SI to 1 in SIII and 13 to 1 for *A.monilifer* and *A.rugosus* respectively. The number of leaves followed the trend of number of branches with more value in SI and less value in SIII in both the species. Reduction of leaves by decreasing the light intensities was more in *A.rugosus* than *A.monilifer*.

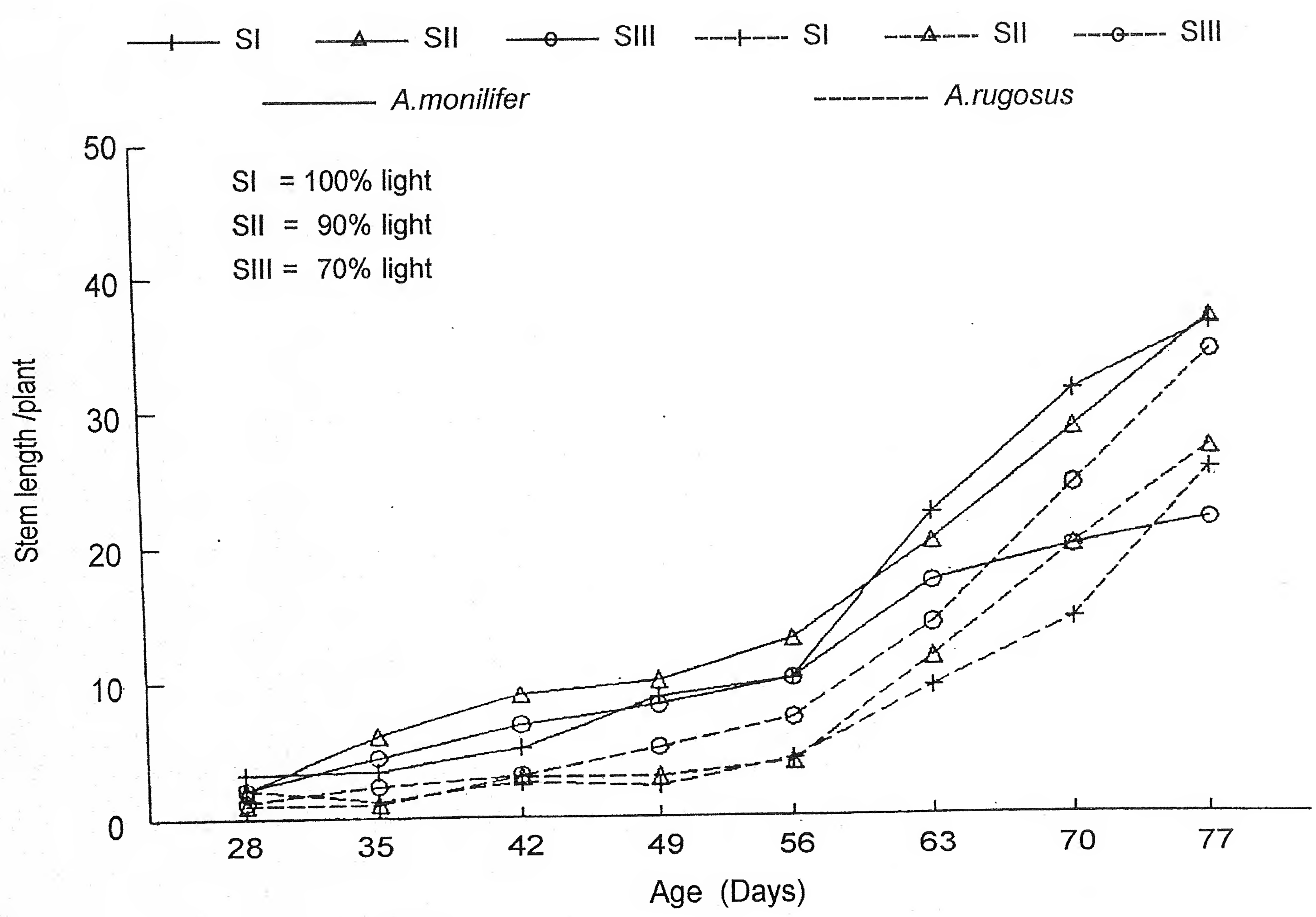

Fig.6.1: Primary growth attributes of two species of *Alysicarpus* (*A.monilifer* & A.*rugosus*) at different ages under varying shading conditions

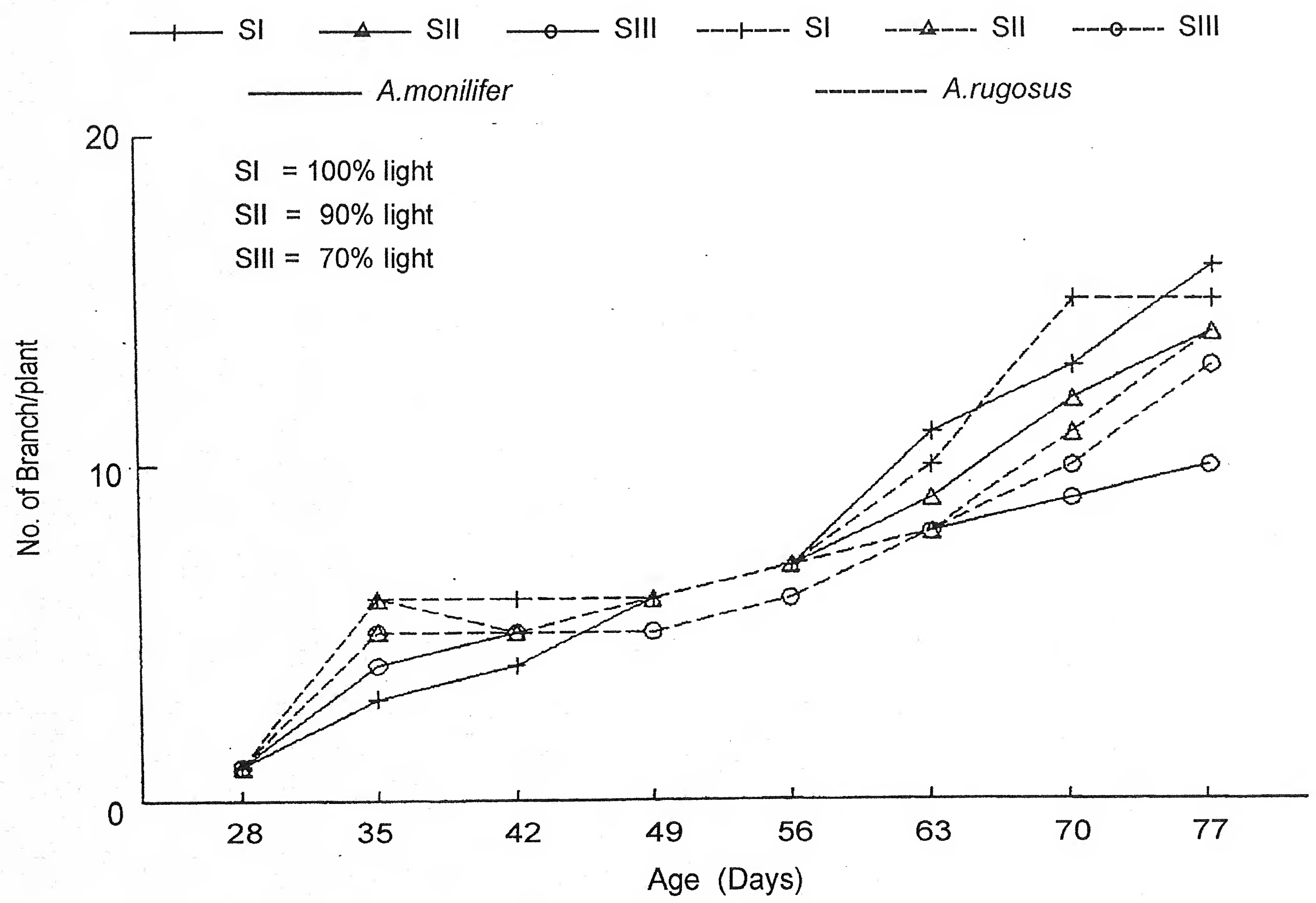

Fig.6.2: Primary growth attributes of two species of *Aysicarpus* (*A.monilifer* & *A.rugosus*) at different ages under varying shading conditions

TABLE 6.1: Primary growth attributes of the two species of *Alysicarpus* (*A.monilifer* and *A.rugosus*) at different ages under varying shading conditions.

Attributes/ Treatments Species	Age (Days)	Number of branches/plant			Stem length/plant			Number of leaves/plant		
		SI	SII	SIII	SI	SII	SIII	SI	SII	SII
A.monilifer	28	1	1	1	3.2	2	2.1	5.0	5.0	4.0
A.rugosus		1	1	1	2.1	1	1.2	6.0	5.0	6.0
A.monilifer	35	3	5	4	3.4	6	4.4	9.0	9	8.0
A.rugosus		6	6	5	1.2	1	2.3	9	8.0	8.0
A.monilifer	42	4	5	5	5.1	9	6.8	12.0	14.0	12.0
A.rugosus		6	5	5	2.6	3	3.1	12	12.0	8.0
A.monilifer	49	6	6	5	8.8	10	8.2	25	20	13.0
A.rugosus		6	6	5	2.3	3	5.1	20	14	11.0
A.monilifer	56	7	7	6	10.1	13	10.1	42	31	17
A.rugosus		7	7	6	4.2	4	7.2	46	31	14

Contd..

TABLE 6.1: Contd.

Attributes/ Treatments Species	Age (Days)	Number of branches/plant			Stem length/plant			Number of leaves/plant		
		SI	SII	SIII	SI	SII	SIII	SI	SII	SII
A.monilifer	63	11	9	8	22.3	20.3	17.2	92.4	41.8	25.3
A.rugosus		10	8	8	9.4	11.6	14.1	85.6	37.4	25.3
A.monilifer	70	13	12	9	31.4	28.6	19.8	166.2	66.8	49.2
A.rugosus		15	11	10	14.4	19.9	24.4	120.2	79.8	50.8
A.monilifer	77	16	14	10	36.4	36.8	21.8	141.3	92.2	73.2
A.rugosus		15	14	13	25.6	27.2	34.3	232.3	122.4	76.3

SI = 100% light; SII = 90% light; SIII = 70% light.

TABLE 6.2: Growth parameters of two species of *Alysicarpus (A.monilifer* and *A.rugosus)* at different ages under varying shading conditions.

Attributes/ Treatments Species	(Days)	Leaf area (cm^2)			Dry weight/plant (mg)		
		SI	SII	SIII	SI	SII	SIII
A.monilifer	28	2.44	2.02	2.05	14.70 ±1.88	7.50 ±1.02	7.01 ±0.38
A.rugosus		2.35	2.01	2.09	8.50 ±1.02	7.88 ±0.28	7.92 ±0.24
A.monilifer	35	4.24	5.01	4.38	18.18 ±0.24	17.35 ±1.20	12.65 ±2.35
A.rugosus		3.14	3.21	4.38	20.25 ±2.17	8.35 ±0.45	8.02 ±0.38
A.monilifer	42	7.20	10.16	9.03	44.75 ±5.62	38.95 ±3.32	26.35 ±3.05
A.rugosus		5.58	6.04	6.02	66.98 ±4.12	15.62 ±1.62	8.12 ±1.32
A.monilifer	49	19.84	24.00	10.53	130.90 ±6.80	140.40 ±7.32	30.40 ±2.12
A.rugosus		10.64	10.01	7.81	113.50 ±5.12	63.47 ±8.12	17.66 ±0.32

Contd....

TABLE 6.2: Contd.

Attributes/ Treatments Species	Age (Days)	Leaf area (cm^2)			Dry weight/plant (mg)		
		SI	SII	SIII	SI	SII	SIII
A.monilifer	56	41.55	33.63	14.34	230.19 ±5.62	142.72 ±5.51	33.18 ±4.12
A.rugosus		29.91	16.89	9.67	140.08 ±14.20	100.00 ±9.08	24.60 ±3.82
A.monilifer	63	126.22	43.78	37.64	670.40 ±30.50	125.10 ±5.50	169.30 ±15.12
A.rugosus		65.99	30.68	33.32	480.82 ±40.12	235.10 ±25.12	140.55 ±10.12
A.monilifer	70	111.06	69.67	35.16	1216.15 ±60.12	590.12 ±12.13	203.81 ±13.16
A.rugosus		95.58	70.65	5.67	654.90 ±9.90	448.06 ±13.12	265.55 ±18.22
A.monilifer	77	107.85	95.70	70.75	1418.78 ±44.24	1032.42 ±115.74	234.72 ±46.45
A.rugosus		125.12	80.32	75.92	1282.32 ±60.12	664.15 ±25.82	392.43 ±31.42

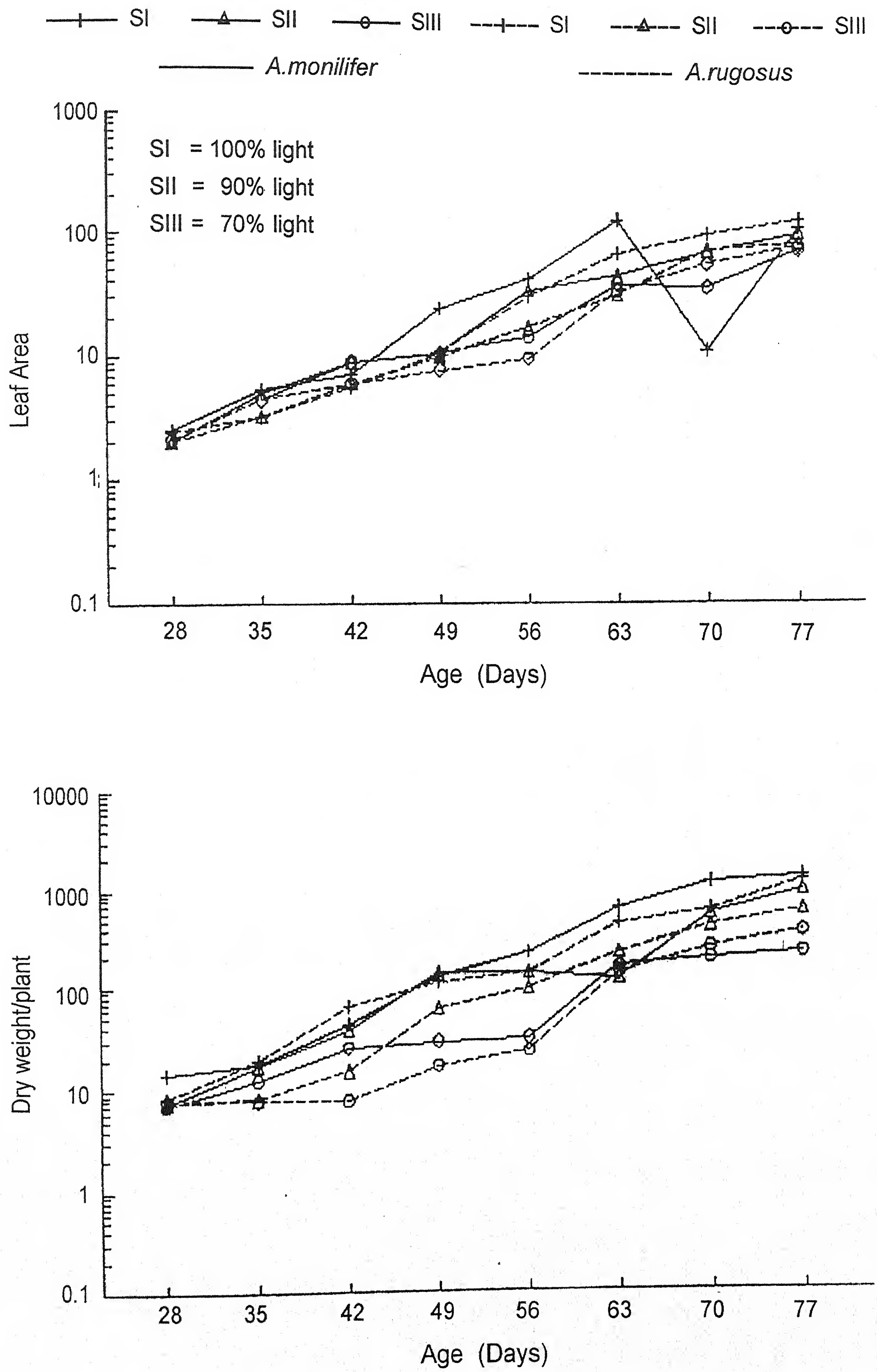

Fig.6.3: Growth parameters of two species of *Alysicarpus* (*A.monilifer* & *A.rugosus*) at different ages under varying shading conditions

TABLE 6.3: Derived g·owth parameters of the two species of *Alysicarpus (A.monilifer* and *A.rugosus)* at harvest under varying shading conditions.

Attributes/ Treatments Species	In between harvest	R G R			N A R		
		SI	SII	SIII	SI	SII	SIII
A.monilifer	1-2	0.22	0.93	0.64	0.97	3.07	1.81
A.rugosus		0.94	0.03	0.02	4.34	0.13	0.02
A.monilifer	2-3	0.98	0.83	0.78	3.80	2.73	2.14
A.rugosus		1.23	0.69	0.01	11.03	1.89	0.01
A.monilifer	3-4	1.08	1.30	0.14	6.23	5.99	0.46
A.rugosus		1.99	1.45	0.84	5.96	6.48	2.03
A.monilifer	4-5	0.55	0.01	0.10	3.36	0.08	0.27
A.rugosus		0.21	0.44	0.35	9.43	2.85	0.97
A.monilifer	5-6	1.06	0.12	1.62	5.76	0.43	5.84
A.rugosus		1.22	0.85	1.77	7.52	6.07	6.42
A.monilifer	6-7	0.59	1.53	0.16	4.74	8.36	0.72
A.rugosus		0.30	0.65	0.63	2.62	5.23	2.98
A.monilifer	7-8	0.15	0.57	0.15	1.75	5.56	0.51
A.rugosus		0.67	0.38	0.37	5.79	3.31	1.98

TABLE 6.4: Derived growth parameters of the two species of *Alysicarpus (A.monilifer* and *A.rugosus)* at harvests under varying shading conditions.

Attributes/ Treatments Species	Age (Days)	L A R			S L R			L W R			S/R Ratio		
		SI	SII	SIII	SI	SII	SIII	SI	SII	SIII	SI	SII	SIII
A.monilifer	28	0.17	0.28	0.33	0.62	0.53	0.55	0.27	0.54	0.61	0.63	3.34	2.98
A.rugosus		0.30	0.15	0.29	0.61	0.50	0.71	0.50	0.31	0.41	2.58	5.75	1.81
A.monilifer	35	0.29	0.30	0.36	0.58	0.63	0.71	0.51	0.47	0.50	3.36	3.14	4.40
A.rugosus		0.15	0.30	0.63	0.59	0.59	0.29	0.26	0.50	2.20	1.76	2.78	10.50
A.monilifer	42	0.20	0.30	0.34	0.43	0.58	0.83	0.46	0.51	0.41	4.18	8.21	3.57
A.rugosus		0.07	0.41	0.75	3.27	0.66	1.56	0.02	0.61	0.48	0.93	7.99	3.11
A.monilifer	49	0.14	0.16	0.34	0.32	0.33	1.11	0.45	0.47	0.30	5.23	4.52	5.30
A.rugosus		0.08	0.14	0.36	0.21	0.27	0.91	0.42	0.51	0.40	3.22	3.52	3.99

TABLE 6.4: Contd.

Attributes/ Treatments Species	Age (Days)	L A R			S L R			L W R			S/R Ratio		
		SI	SII	SIII	SI	SII	SIII	SI	SII	SIII	SI	SII	SIII
A.monilifer	56	0.17	0.22	0.40	0.36	0.51	1.05	0.47	0.43	0.37	4.20	7.96	3.42
A.rugosus		0.20	0.15	0.36	0.30	0.28	0.78	0.68	0.54	0.45	7.81	4.61	5.41
A.monilifer	63	0.18	0.33	0.21	0.43	0.74	0.48	0.42	0.45	0.44	4.28	11.40	7.87
A.rugosus		0.13	0.12	0.22	0.27	0.30	0.52	0.48	0.40	0.42	2.24	3.45	6.33
A.monilifer	70	0.08	0.11	0.26	0.32	0.49	0.66	0.28	0.23	0.38	5.53	9.57	4.01
A.rugosus		0.14	0.11	0.10	0.06	0.36	0.57	0.53	0.32	0.34	3.32	4.00	5.80
A.monilifer	77	0.07	0.08	0.29	0.33	0.43	0.84	0.21	0.20	0.35	5.41	7.74	0.14
A.rugosus		0.07	0.11	0.18	0.38	0.39	0.58	0.24	0.28	0.31	3.62	4.54	5.27

TABLE 6.5: Analysis of variance for the data on dry matter accumulation, leaf area and LAR.

Source of variation	Degree of freedom	Dry weight		Leaf area		LAR	
		MS	F	MS	F	MS	F
Sp.	1	4406.7	1.9	686.9	8.9*	0.0002	46.6
Tr.	2	46657.3	20.2**	789.8	10.3**	0.1375	12.0**
Har.	5	73609.2	31.9***	2418.5	31.5***	0.0244	2.3
Tr. x Sp.	2	1364.4	1.7	102.3	1.3	0.0227	2.1
Tr. x Har.	10	16664.9	7.2**	406.3	5.2	0.0105	1.0
Har. x Sp.	5	623.7	3.7	132.2	1.7	0.0081	0.8
Residual	10	2303.2		77.7		0.0106	

* = Signifiant at 5% level; ** = Significant at 1% level; *** = Significant at 0.1% level.

TABLE 6.6: Analysis of variation for the data of RGR and NAR.

Source of variation	Degree of freedom	R G R		N A R	
		MS	F	MS	F
Sp.	1	0.0963	1.6	6.7119	1.2
Tr.	2	0.3028	1.9	24.1719	4.4*
Har.	4	0.8757	5.5*	17.2407	3.1
Tr. x Sp.	2	0.1137	1.4	3.3756	1.6
Tr. x Har.	8	0.3390	2.1	6.1039	1.1
Har. x Sp.	4	0.1998	1.2	2.0331	2.7
Residual	8	0.1585		5.4918	

TABLE 6.7: Reproductive growth attributes of two species of *Alysicapus* (*A.monilifer* and *A.rugosus*) different ages under varying shading conditions.

Attributes/ Treatments	Dates of flowering primodia after seed sowing			Number of inflorescence/plant			Number of flower/plant		
Species	SI	SII	SIII	SI	SII	SIII	SI	SII	SII
A.monilifer	66	73	80	33	25	16	600	775	349
A.rugosus	64	72	76	79	39	10	1771	812	159

TABLE 6.7: Contd.

Attributes/ Treatments Species	Number of fruit/plant			Dry weight of fruit/plant (mg)		
	SI	SII	SIII	SI	SII	SIII
A.monilifer	155	177	-	154	109	-
A.rugosus	268	185	-	80	66	-

TABLE 6.8: Effect of varying shading conditions on chlorophyll content.

Attributes/ Treatments Species	Age (Days)	mg Chlorophyll a/g fresh weight tissue			mg cholorophyll b/g fresh weight tissue			mg total chlorophyll/g fresh weight tissue		
		SI	SII	SIII	SI	SII	SIII	SI	SII	SIII
A.monilifer	35	0.51	0.66	0.56	0.53	1.01	0.92	1.02	1.67	1.48
A.rugosus		0.58	0.61	0.58	0.90	0.95	0.96	1.48	1.56	1.54
A.monilifer	42	0.48	0.63	0.58	0.81	1.14	0.96	1.29	1.77	1.54
A.rugosus		0.66	0.66	0.67	1.01	1.10	1.14	1.67	1.76	1.81
A.monilifer	49	0.52	0.68	0.69	0.85	1.18	1.05	1.37	1.86	1.74
A.rogosus		0.73	0.70	0.78	1.03	1.22	1.18	1.76	1.92	1.96
A.monilifer	56	0.65	0.76	0.81	1.02	1.24	1.09	1.67	2.00	1.90
A.rugosus		0.71	0.77	0.85	1.13	1.28	1.54	1.84	2.05	2.39
A.monilifer	63	0.73	0.83	0.90	1.14	1.32	1.56	1.87	2.15	2.46
A.rogosus		0.78	0.87	0.98	1.26	1.51	1.75	2.04	2.38	2.73
A.monilifer	77	0.75	0.87	0.96	1.16	1.33	1.69	1.91	2.20	2.65
A.rugosus		0.74	0.93	0.78	1.10	1.51	1.36	1.84	2.44	2.14

Dry matter accumulation was noticed maximum in SI and minimum in SIII in both the species. The magnitude of reduction was equal (75%) in both the species. However, *A.monilifer* registered more dry matter accumulation than *A.rugosus* at three different light intensities (100%, 90% and 70%). The data were found significant for Tr, Har and Tr x Har at 0.1% level of probability (Table 6.5).

Relative growth rate (Table 6.3) varied from 0.98 mg mg^{-1} $week^{-1}$ to 0.78 mg mg^{-1} $week^{-1}$ and from 1.99 to 0.84 mg mg^{-1} $week^{-1}$ with more value in SI and less value in SIII in *A.monilifer* and *A.rugosus* respectively. The data was found significant for harvest at 5% level of probability.

Net assimilation rate was found maximum in SI and with decreasing light intensities it diminished sharply. It varied from 6.23 to 0.46 mg cm^{-2} $week^{-1}$ for *A.monilifer*. The same for *A.rugosus* varied from 11.03 to 0.01 mg cm^{-2} $week^{-1}$ with maximum value in SI and minimum in SIII. The data were found significant for Treatment at 5% level (Table 6.3).

The leaf area ratio (LAR) displayed inverse relationship with the light intensity being lowest in SI and highest in SIII. This trend was maintained for both the species. Magnitude of ehancement was higher in *A.rugosus* as compared to *A.monilifer*.

The data was found significant for treatment only at 1% level.

Specific leaf area varied from 0.36 cm^2/mg to 1.05cm^2/mg and from 0.30 cm^2/mg to 0.78 cm^2/mg with higher value in SIII and lower value in SI for *A.monilifer* and *A.rugosus* respectively. Although some ambiguous relationship was observed for *A.rugosus* at the early stages of growth and development. The value diminished in both the species at the later stages of growth and development. Leaf weight ratio displayed higher value in SII in both the species and diminishing in SI and SIII. Deviation of SII value was more in *A.rugosus* in comparison to *A.monilifer*. Shoot-root ratio (Table 6.4) was maximum in SII than SI and SIII for *A.monilifer*, while the same for latter species was higher in SIII and lower in SI and SII.

The initiation of flowering (Table 6.7) started after 65 and 63 days after sowing in case of *A.monilifer* and *A.rugosus* respectively. As regards the mean number of inflorescence per plant, it varied from 33 in SI to 16 in SIII in *A.monilifer* while 79 to 10 for *A.rugosus* in SI and SIII regimes, respectively.

Number of flowers/plant were 600, 775 and 349 in *A.monilifer* while 771, 812 and 159 in *A.rugosus* in three respective intensities of light. As regards the number of fruits per plant it varied from 155 in SI to 177 in SII in *A.monilifer* while 268 to 185

in *A.rugosus*. It is worth noting that SIII plant did not bear any fruit. With regard to dry weight of fruit/plant it ranged from 154 mg to 109 mg in SI and SII, conditions respectively, for *A.monilifer* but it ranged from 80 to 66 mg for *A.rugosus*.

Value of total chlorophyll/g fresh weight tissue (Table 6.8 and Fig. 6.4) was maximum in SIII condition (2.46) and minimum in SI condition (1.87) for *A.monilifer* and maximum in SIII regime (2.73) and minimum in SI regime (2.04) for *A.rugosus*. Chlorophyll content increased upto 63 days of sowing in *A.rugosus* but in increased upto 63 and onward days of sowing in *A.monilifer*. *A.rugosus* displayed higher value of chlorophyll content than *A.monilifer*. Chlorophyll a and chlorophyll b had the same trend like total chlorophyll in both the species of *Alysicarpus (A.monilifer* and *A.rugosus)*.

DISCUSSION

From the results it is evident that in both the species more branching occurred under full illumination and that with the reduction in light intensity less branches emerged. Number of leaves strictly followed the pattern of branching in both the species. In this context it is worth nothing that *A.rugosus* had an edge over the other species. Further more number of leaves in 90% light in *A.monilifer* over the 3rd and 4th harvests lies in agreement with

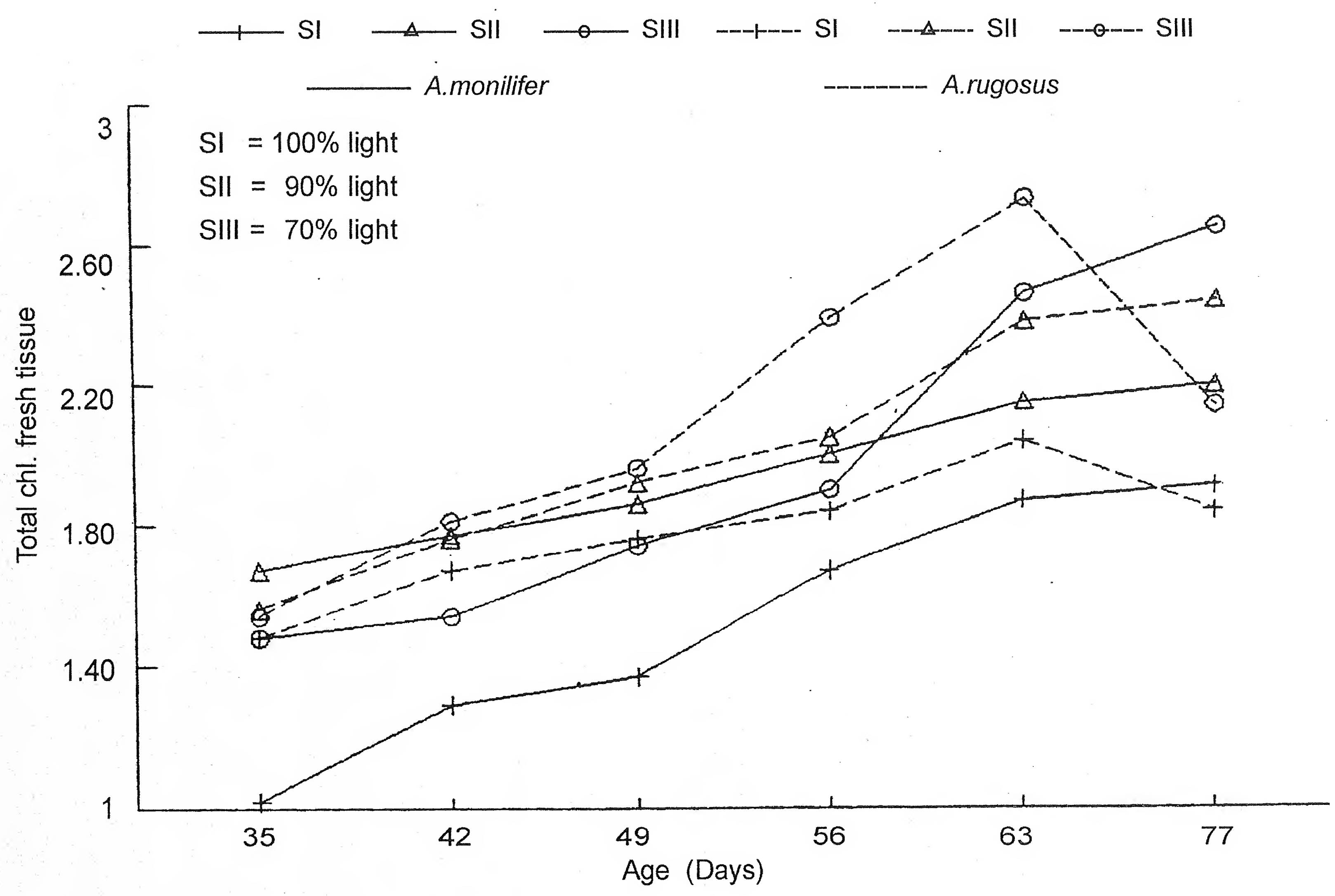

Fig.6.4: Effect of varying shading conditions on chlorophyll content

those of Warrington *et al.* (1978), Goel and Pandey (1983). Reduction of light intensity upto 10% caused longer plant in both the species while curtailment of light to 70% caused diminishing effect. The difference in the two species could be noticed on the basis of their leaf area. The magnitude of decrease in *A.monilifer* being 35% and in *A.rugosus* being 40% ensured that *A.monilifer* is more adaptive for shady environment. The higher leaf area in 100% light is reflective of the more dry matter accumulation.

From the data of dry weight accumulation, the two species appeared identical in displaying equal percentage of decrease in 70% solar radiation, but a milder reduction to the extent of 90% light indicated better performance corroborating the contention of Blackman and Wilson (1951); Evans and Hughes (1962); Myerscough and Whitehead (1957); Packam and Willis (1982); that some plants in tropical regions performed better under slightly less than the full solar insolation. The sizeable reduction to the extent of 70% definitely caused poor dry weight accumulation in which *A.monilifer* displayed more adaptability as compared to *A.rugosus*. Data on RGR indicated a position response of light intensity in both the species particularly during the early vegetative stage. The reduction of RGR with shading has been observed by several workers (Evans and Hughes, 1962; Eagles, 1973; Pandey and Sinha, 1977; Packham and Willes, 1982).

The linear relationship of NAR with light was evident for the two species as has been observed by Hodgon (1967). The reduction of RGR appeared largely due to lesser values of NAR under reduced light intensity. Nilwik (1981). Packham and Willis (1982) have also noted such relationship. The former has attributed the significant effect of respiratory losses during nictoperiod for plants under low level of illumination. The enhancement of LAR with decreasing light intensity corroborates the idea of many workers (Blackman and Wilson, 1961; Evans and Hughes, 1962; Myerscough and Whitehead, 1967; Packam and Willis, 1982) who have found similar results with the enhancement of this ratio with decreasing light intensity. From a decline of value in the subsequent harvests it is apparent that a single growth phase cycle existed in both the species. From the SLA component of the LAR, the differential behaviour of the two species was noted as having higher SLA in *A.monilifer* . Also in both the species the maintenance of LAR appeared reflective of the corresponding behaviour of SLA. This situation has been marked by Nilwik (1981). The higher values of SLA under shaded condition has also been observed by Evans and Hughes (1962) and Puckham and Willis (1982). The maturity of the leaves as indicated by LWR could not be observed very much under the three light intensities in both the species.

Warrington *et at*. (1978) have observed that the LAR decreased with increased light intensities for which the contribution of LWR and SLA were proportionate.

As regards shoot/root ratio it has been reported that it reduces with shading (Yamasaki and Ujike, 1983). However, in the present case no significant difference could be marked from this attribute. From the delayed floral initiation in shaded plant of both the species it can be inferred that higher light is favourable for floral initiation as observed by Goel (1983). From number of inflorescence per plant it could be inferred that shade growing plants are least capable for reproductive process. Absence of fruit in SIII condition could be explained on the basis that shade is not favourable for fruiting in both the species.

The variabilities of two species may be marked on the basis that *A.monilifer* had lower chlorophyll content in comparison to *A.rugosus*. Minimum Chlorophyll in SI condition lay in view of Ball and Critchley (1982). From the higher chlorophyll value in SIII and SII condition, the shade tolerance of both the species could be marked.

CHAPTER - VII

EFFECT OF SOIL MOISTURE ON GROWTH

INTRODUCTION

The fact that the absence of moisture from the soil causes depletion of vegetation in any habitat` has long been realised. As such the relationship of plants with the availability and status of water in the soil has drawn the attention of workers from the ancient times. The authentic experimentation on this aspect. however, was started by Fowler and Lipman (1971). They reported the adaptability of lemon tress to a wide range of soil moisture. Clements and Long (1935) utilised the concept of growth analysis for finding out the effect on RGR, NAR, LAR etc. A good number of workers (Went, 1944; Cykler. 1946; Davis, 1940; Daubenmire and Charter, 1942; Veihmayer and Hendrison, 1950) found that the growth was independent of water stress in the range of soil moisture above permanent willing percentage prevailed during those days. On the other hand, some workers (Watson, 1952; Blackman and Bunting, 1954) found some different results after applying growth analysis technique. William and Shapter (1955) observed the increase of NAR with higher soil water content. Brix (1962) found diminishing of leaf area of tomato plants in similar condition. As regards the RGR, various workers (Pope and Magdwick, 1974; Wilson and Allison, 1978; Fisher and Edward, 1982; Pandey, 1985;

Pandey and Goel, 1986) have found its reduction with decreasing soil moisture. Later it was realised by various workers (Walter, 1958; Parsons, 1969) that besides general growth, partitioning pattern of assimilates to different plant parts, i.e., in the shoot and root was affected. Daubenmire (1974) in fact has generalised that there is a decrease of shoot/root ratio with decreasing soil moisture.

The comparative ecophysiological approach with regard to soil moisture is almost a recent innovation for comparing the adaptability of taxa (Whitehead and Myerscough, 1962; Shamsi and Whitehead, 1976; Daniel *et al.*, 1985). Most of the earliest workers concentrated towards finding out the effect on the economic yield of the plants. The two species under reference faced the differential soil moisture conditions with almost water logging during the September and October to near xeric condition during the summer months (March and April). As such, it was considered useful to compare their growth performance in a range of soil moisture by resorting to varying irrigational regimes of the pots.

MATERIALS AND METHODS

Irrigational Regimes

To examine the effect of different soil moisture regimes, four irrigational cycles were maintained in the following way:

WL Waterlogged condition was created by plugging the bottom hole of the pot with the help of wax. Further the care was taken that about 1/2 cm water remained on the surface of the soil.

WAD Pots watered to field capacity every alternate day.

W4D Pots watered to field capacity every 4th day.

W6D Pots watered to field capacity every 6th day.

RESULTS

The results have been presented on Table 7.1 to 7.9. The mean percentage of soil moisture of the two species under different watering regimes has been given in Table 7.1.

As in Table 7.2 number of branches were reduced in waterlogged as well as in W6D in comparison to alternate day watering and fourth day watering in both the species. The number of branches was more in *A.rugosus* than *A.monilifer* at all the treatments.

As regards the length of stem, *A.monilifer* was longer than *A.rugosus* (Table 7.2 and Fig. 7.1). This feature of *A.monilifer* was noted at varying ages under different watering regimes. Except at later stages of growth in water logged condition, the reverse case was found. The number of leaves was maximum in alternate day watering. It decreased in

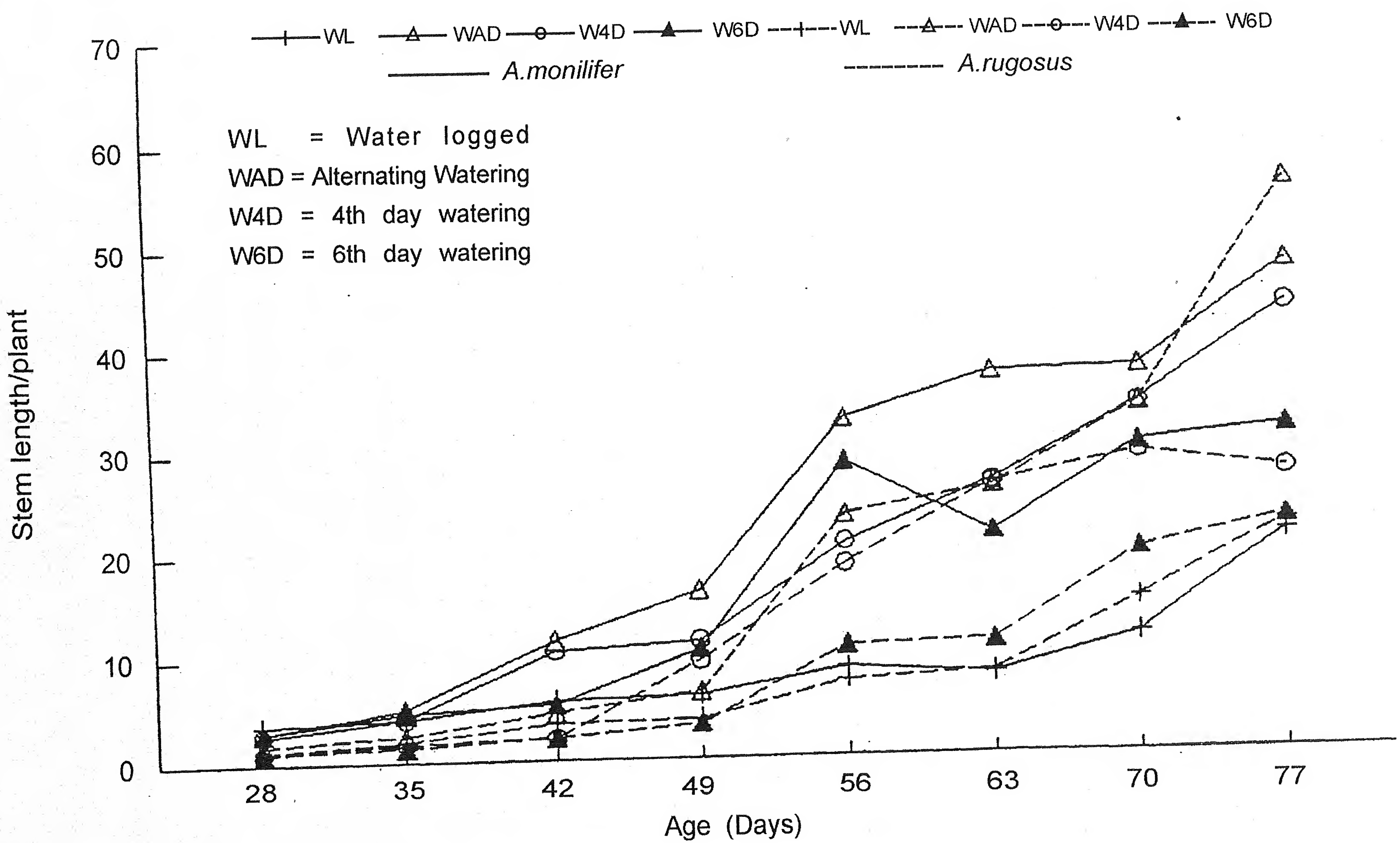

Fig.7.1: Primary growth attributes of two species of *Alysicarpus* (*A.monilifer* & *A.rugosus*) at different harvest under varying watering regimes

waterlogged condition as well as in water stressed condition. However, *A.monilifer* had more reduction of leaves in waterlogged condition than W6D condition. But *A.rugosus* behaved differently in having lesser reduction of leaves in WL condition than W6D plant than waterlogged plant. More number of leaves were found in *A.rugosus* in comparison to *A.monilifer* (Table & Fig. 7.2).

The dry matter accumulation was maximum in WAD plant of *A.monilifer* from 1st to the last harvest. The values were in the reducting order both in the drier as well as in waterlogged regimes, with maximum reduction in waterlogged. The other species appeared with maximum dry matter in WAD and W4D plants in comparison to waterlogged and 6th day watering plants. Here also the values were in the reducing order both in the drier as well as in waterlogged but maximum reduction was in W6D plants. Dry weight of plant (mg) increased initially upto 70 days in *A.rugosus* in the sets watered on 4th day and 6th day while in *A.monilifer* in the set water on 6th day only. Although increase in dry matter accumulation upto last harvest was noticed in waterlogged and alternate day watering plant of both the species but no clear-cut variation with respect to two species was marked at any level of watering. The data was found significant for species, treatment, harvest and interaction Tr. x Har. at 0.1% level (Table 7.3).

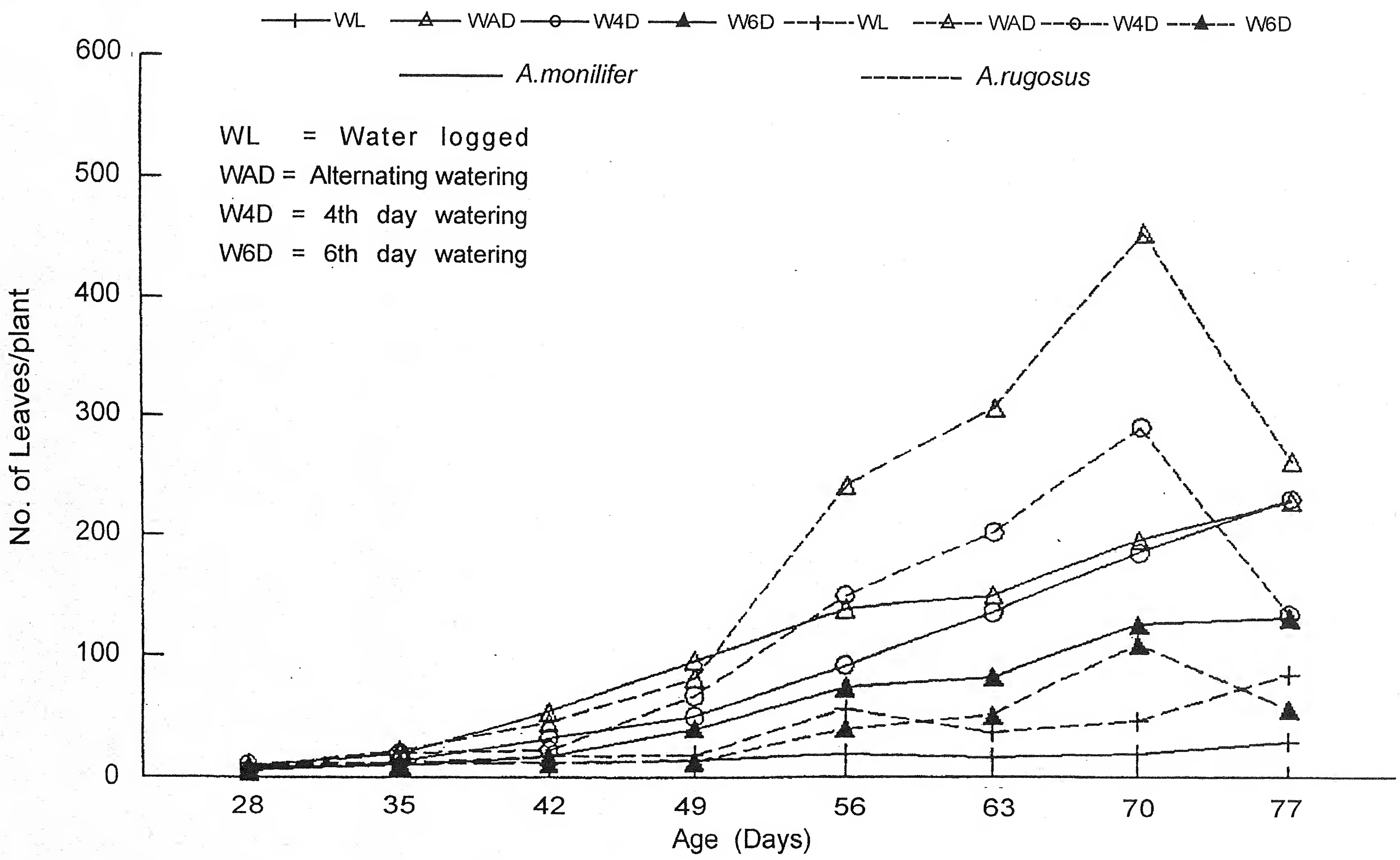

Fig.7.2: Primary growth attributes of two species of *Alysicarpus* (*A.monilifer* & *A.rugosus*) at different harvest under varying watering regimes

TABLE 7.1: Percentage of soil moisture under varying soil moisture regimes just before rewatering.

Treatments/ Species	WL	WAD	W4D	W6D
A.monilifer	75.1	21.2	8.0	2.7
A.rugosus	70.0	15.3	9.1	3.4

WL= Water logged; WAD = Watered every alternative day; W4D = Water every fourth day; W6D = Watered every sixth day.

TABLE 7.2: Primary growth attributes of the two species of *Alysicarpus (A.monilifer* and *A.rugosus)* at diffefent harvest under varying watering regimes.

Attributes/ Treatments Species	Age (Days)	Number of branches/plant				Stem length/plant				Number of leaves/plant			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	28	3	5	2	5	3.7	3.0	2.7	3.0	8	9	6	5
A.rugosus		4	4	3	4	1.2	1.7	1.0	1.1	11	9	10	9
A.monilifer	35	3	6	4	6	4.1	5.1	4.1	4.7	10	19	13	10
A.rugosus		5	6	5	5	2.0	2.5	1.7	1.4	12	22	20	11
A.monilifer	42	5	8	6	5	5.8	11.5	10.5	5.4	12	54	32	17
A.rugosus		6	6	6	4	3.6	4.6	2.2	2.2	17	45	22	12
A.monilifer	49	4	10	7	7	6.1	16.1	11.3	10.5	14	96	50	40
A.rugosus		7	8	8	5	3.8	6.4	9.4	3.4	18	81	67	13
A.monilifer	56	7	13	11	9	8.5	32.7	20.6	28.5	19	139	92	74
A.rugosus		10	31	13	8	7.3	23.3	18.5	10.6	56	243	150	40

Contd..

TABLE 7.2: Contd.

Attributes/ Treatments Species	Age (Days)	Number of branches/plant				Stem length/plant				Number of leaves/plant			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	63	5	14	12	10	7.7	37.1	26.4	21.4	16	150	136	82
A.rugosus		8	34	16	9	7.9	25.9	26.2	10.9	37	308	203	51
A.monilifer	70	7	13	14	14	11.4	37.5	34.0	30.1	19	197	186	126
A.rugosus		10	19	17	15	14.8	33.9	29.1	19.6	46	455	292	109
A.monilifer	77	8	20	14	15	21.0	47.5	43.4	31.5	29	229	231	131
A.rugosus		13	25	17	14	22.1	55.4	27.2	22.5	84	263	134	56

TABLE 7.3: Growth parameters of two species of *Alysicarpus (A.monilifer & A.rugosus)* at different ages under varying moisture regimes.

Attributes/ Treatments Species	Age (Days)	Dry matter accumulation/plant				Leaf area (cm^2)			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	28	21.80 ±1.2	35.7 ±7.8	16.4 ±3.2	15.1 ±1.2	3.7	8.5	3.1	3.3
A.rugosus		23.70 ±1.3	15.8 ±0.1	36.2 ±1.2	18.1 ±1.3	5.1	4.5	5.7	3.4
A.monilifer	35	27.10 ±3.5	74.1 ±5.8	38.8 ±1.3	58.3 ±6.8	4.2	13.5	9.4	10.1
A.rugosus		37.10 ±2.8	64.7 ±10.1	59.7 ±4.6	28.3 ±2.4	6.4	13.1	12.4	6.4
A.monilifer	42	58.50 ±9.1	253.2 ±10.1	156.2 ±31.3	98.2 ±8.4	5.7	48.1	21.6	10.2
A.rugosus		86.20 ±3.3	214.3 ±16.8	29.1 ±4.6	34.4 ±3.6	8.8	36.3	16.0	12.3
A.monilifer	49	59.0 ±1.6	496.3 ±17.2	196.6 ±6.5	211.7 ±15.3	5.9	110.1	43.3	15.6
A.rugosus		90.0 ±6.5	361.2 ±8.3	251.7 ±10.5	42.3 ±14.3	11.2	66.4	45.1	13.2

Contd..

TABLE 7.3: Contd.

Attributes/ Treatments Species	Age (Days)	Dry matter accumulation/plant				Leaf area (cm^2)			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	56	82.9 ±3.9	1084.3 ±100.3	480.2 ±74.2	545.6 ±31.8	7.5	133.0	97.7	57.8
A.rugosus		190.3 ±31.4	1320.6 ±160.4	535.4 ±36.5	161.7 ±13.3	33.0	196.8	78.1	22.1
A.monilifer	63	93.5 ±3.3	1611.8 ±200.8	835.1 ±65.4	609.8 ±69.5	10.2	143.1	114.2	78.9
A.rugosus		243.2 ±9.8	2258.6 ±90.4	1031.7 ±101.4	210.4 ±21.9	39.7	361.2	159.1	29.5
A.monilifer	70	192.1 ±27.4	1723.1 ±300.4	1572.5 ±50.4	761.2 ±72.5	15.0	196.2	192.8	107.2
A.rugosus		290.2 ±30.4	359.30 ±180.3	2074.9 ±208.3	643.6 ±65.4	25.8	294.3	158.9	55.5
A.monilifer	77	230.3 ±52.8	4930.90 ±260.15	2445.3 ±40.38	226.9 ±170.4	20.7	145.8	138.1	88.3
A.rugosus		556.5 ±20.6	8980.1 ±301.5	1751.5 ±172.4	1041.10 ±65.6	20.6	169.4	55.7	18.3

TABLE 7.4: Derived growth parameters of the two species of *Alysicarpus (A.monilifer* and *A.rugosus*) between harvests under varying watering regimes.

Attributes/ Treatments Species	Harvest in between	RGR				NAR			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	1-2	0.17	0.70	0.81	1.29	1.16	3.32	3.70	6.55
A.rugosus		0.21	1.36	0.48	0.42	2.28	5.79	2.56	2.32
A.monilifer	2-3	0.77	1.21	1.36	0.50	6.70	6.21	7.34	4.66
A.rugosus		0.41	1.17	0.48	0.17	5.97	6.25	2.93	0.65
A.monilifer	3-4	0.01	0.67	0.22	0.75	0.08	3.22	1.26	8.14
A.rugosus		0.21	0.51	0.93	0.85	0.33	2.87	5.32	0.63
A.monilifer	4-5	0.31	0.77	0.88	0.94	3.46	4.63	4.15	9.98
A.rugosus		0.97	1.28	0.74	1.57	4.68	7.94	4.61	6.51
A.monilifer	5-6	0.12	0.38	0.54	0.65	1.17	4.14	3.53	0.91
A.rugosus		0.12	0.53	0.65	0.26	1.41	3.42	4.28	1.80

TABLE 7.4: Contd.

Attributes/ Treatments Species	Harvest in between	R G R				N A R			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	6-7	0.70	0.06	0.62	0.39	7.85	0.64	4.86	1.59
A.rugosus		0.16	0.42	0.68	1.10	1.44	3.58	11.33	10.18
A.monilifer	7-8	0.18	1.04	0.43	1.12	2.21	18.47	5.25	10.18
A.rugosus		0.41	1.17	0.48	0.17	5.97	6.25	2.93	0.65
A.monilifer	8-9	0.01	0.67	0.22	0.75	0.08	3.22	1.26	8.14
A.rugosus		0.18	0.94	0.46	11.11	1.71	24.20	3.22	11.50

TABLE 7.5: Derived growth parameters of the two species of *Alysicarpus (A.monilifer & A.rugosus)* at harvest under varying watering regimes.

Attributes/ Treatments Species	Age (Days)	L A R				L W R				S L A				S/R Ratio			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D	WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	28	0.16	0.23	0.17	0.20	0.52	0.60	0.52	0.47	0.31	0.37	0.32	0.43	6.41	5.12	3.15	4.54
A.rugosus		0.20	0.27	0.15	0.17	0.45	0.59	0.61	0.51	0.71	0.45	0.24	0.34	2.95	4.75	5.77	2.73
A.monilifer	35	0.15	0.18	0.26	0.18	0.47	0.67	0.65	0.56	0.32	0.30	0.39	0.32	7.44	10.03	9.20	4.86
A.rugosus		0.16	0.20	0.21	0.18	0.47	0.66	0.71	0.57	0.35	0.31	0.30	0.31	3.11	6.66	11.13	5.67
A.monilifer	42	0.08	0.18	0.14	0.10	0.37	0.50	0.41	0.46	0.21	0.37	0.34	0.23	12.85	4.90	5.10	3.62
A.rugosus		0.10	0.16	0.17	0.37	0.46	.45	0.48	0.27	0.23	0.37	0.35	1.36	3.92	2.81	2.88	1.73
A.monilifer	49	0.09	0.21	0.21	0.07	0.38	0.46	0.39	0.45	0.26	0.46	0.55	0.16	4.22	4.09	4.91	5.68
A.rugosus		0.13	0.18	0.17	0.32	0.35	0.47	0.48	0.41	0.37	0.38	0.37	0.78	1.91	2.64	2.96	4.13
A.monilifer	56	0.08	0.11	0.20	0.10	0.32	0.38	0.36	0.34	0.27	0.31	0.54	0.30	5.21	3.99	4.08	3.21
A.rugosus		0.16	0.14	0.14	0.13	0.42	0.38	0.40	0.36	0.40	0.37	0.35	0.38	4.32	5.04	4.66	2.58
A.monilifer	63	0.10	0.08	0.13	0.12	0.30	0.34	0.40	0.38	0.35	0.25	0.32	0.32	3.99	4.73	5.68	4.26
A.rugosus		0.03	0.15	0.14	0.14	0.21	0.33	0.34	0.36	0.17	0.46	0.43	0.37	3.26	8.08	7.71	2.27
A.monilifer	70	0.07	0.10	0.11	0.13	0.16	0.35	0.27	0.40	0.44	0.42	0.44	0.34	0.74	4.37	4.37	4.48
A.rugosus		0.04	0.08	0.07	0.08	0.06	0.19	0.17	0.22	0.80	0.42	0.42	0.37	1.70	5.40	4.08	1.75
A.monilifer	77	0.08	0.02	0.05	0.38	0.26	0.19	0.15	0.15	0.35	0.14	0.34	0.24	6.56	4.33	4.96	4.46
A.rugosus		0.04	0.01	0.02	0.01	0.16	0.42	0.06	0.13	0.28	0.19	0.48	0.13	5.20	5.28	5.07	2.16

WL = Water logged: WAD = Alternate day watering; W4D= Fourth day watering; W6D = Sixth day watering.

TABLE 7.6: Analysis of variance for the data on dry matter accumulation, leaf area and LAR under different soil moisture regimes.

Source of variation	df	Dry matter accumulation		Leaf area		L A R	
		MS	F	MS	F	MS	F
Sp.	1	1318.8	13.34	1071.30/	1.18	0.008	2.67
Tr.	3	742639.1	42.21	16672.06	13.27	0.008	2.71
Har.	5	889963.1	50.58	15861.27	12.63	0.008	2.65
Sp. x Tr.	3	47915.1	2.71	1393.4	1.10	0.006	2.02
Trx x Har.	15	194555.1	11.05	3141.50	2.49	0.002	1.51
Har. x Sp.	5	10144.2	1.72	1330.91	1.05	0.001	1.67
Error	15	17589.2		1256.20		0.003	
Total	47						

*** = Significant at 0.1% level; ** = Significant at 1% level; * = Significant at 5% level.

TABLE 7.7: Analysis of variance for the data on RGR and NAR under different soil moisture regimes.

Source of variation	df	R G R		N A R	
		MS	F	MS	F
Sp.	1	0.0006	146.72	3.457	1.16
Tr.	3	0.5541	6.24**	7.525	2.54
Har.	5	0.3551	4.00*	16.220	5.50**
Sp. x Tr.	3	0.0814	1.08	10.951	3.68*
Tr. x Har.	12	0.1028	1.15	4.979	1.69
Har. x Sp.	4	0.2600	2.25	2.338	1.25
Error	12	0.0886		2.956	
Total	39				

*** = Significant at 0.1% level: ** = Significant at 1% level: * = Significant at 5% level.

TABLE 7.8: Effect of varying watering regimes on chlorophyll content.

Attributes/ Treatments Species	Age (Days)	mg Chlorophyll a/ fresh weight tissue				mg Chlorophyll b/ fresh weight tissue				mg total Chlorophyll/ fresh weight tissue			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	35	0.46	0.52	0.60	0.47	0.67	0.84	0.99	0.80	1.13	1.36	1.59	1.27
A.rugosus		0.36	0.56	0.54	0.43	0.55	0.87	0.82	0.71	0.92	1.44	1.36	1.14
A.monilifer	49	0.31	0.72	0.71	0.57	0.48	1.37	1.17	0.87	0.79	2.10	1.88	1.44
A.rugosus		0.48	0.69	0.80	0.68	0.77	1.15	1.33	1.14	1.25	1.85	2.14	1.82
A.monilifer	63	0.43	0.59	0.65	0.58	0.67	0.97	1.02	0.93	1.11	1.56	1.65	1.52
A.rugosus		0.47	0.74	0.80	0.66	0.70	1.22	1.38	1.08	1.17	1.97	2.17	1.74
A.monilifer	77	0.28	0.62	0.60	0.47	0.38	1.05	1.02	0.69	0.67	1.67	1.61	1.16
A.rugosus		0.58	0.67	0.56	0.76	1.04	1.06	0.97	1.13	1.63	1.72	1.52	1.89

TABLE 7.9: Reproductive growth attributes of the two species of *Alysicarpus (A.monilifer* and *A.rugosus*) under varying water regimes.

Attributes/ Treatments Species	Age (Days)	Day of flowering primordia after seed sowing				Number of inflorescence/plant			
		WL	WAD	W4D	W6D	WL	WAD	W4D	W6D
A.monilifer	28	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	35	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	42	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	49	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	56	61	51	45	42	2	30	23	15
A.rugosus		54	49	44	46	5	63	42	10
A.monilifer	63	-	-	-	-	2	36	28	20
A.rugosus		-	-	-	-	6	120	82	15
A.monilifer	70	-	-	-	-	3	42	44	23
A.rugosus		-	-	-	-	15	182	147	33
A.monilifer	77	-	-	-	-	4	10	52	48
A.rugosus		-	-	-	-	35	268	247	45

The leaf area also corresponded to those of dry weight with more area in WAD and W4D plants of both the species. Marked reduction of *A.monilifer* in waterlogged condition was observed. The magnitude of reduction fluctuated in *A.rugosus* with more reduction in W6D at an early stage of growth, but at the mid harvests more reduction was found in WL plant, again reduction was higher in W6D plant at the letter two harvests. Leaf area of plant increased initially upto 63 days, after which the leaf area values gradually decreased in both the species and in all the watering levels except in waterlogged plant where *A.monilifer* continued to increase upto last harvests. More leaf area was observed in *A.rugosus* than *A.monilifer* in waterlogged and alternate day watered plant while higher leaf area were evidence in *A.monilifer* than *A.rugusos* in 4th day and 6th day watered plant. The data was found significant at 0.1 percent level for treatment and harvest while at 5.0% level for interaction Tr. x Har. (Table 7.3).

Relative growth rate, net assimilation rates, leaf area ratio of *A.monilifer* and *A.rugosus* grown under different watering levels followed more or less a decreasing trend with the age of the plant. Values of RGR varied from 1.16 to 0.21 of *A.rugosus* in alternate day and waterlogged plant at 1st and 2nd harvest interval. The same for *A.monilifer* varied from 1.29 to 0.17 in W6D and WL plant. At

the 2nd and 3rd harvest interval *A.monilifer* showed higher value in alternate day and 4th day watered plant in comparison to waterlogged and W6D plant. At this stage of growth and development *A.rugosus* also displayed higher value of RGR kin alternate day watered plant in comparison to excess watering and under watering regimes, right from 3-4 to 5-6 harvest interval. *A.monilifer* had maximum RGR in W6D plant while *A.rugosus* displayed maximum value in W4D plant at 3rd and 4th harvest but at 4th and 5th harvest maximum values were obtained in W6D plant. The trend again changed at 5th and 6th harvest where maximum values were found in W4D plant. Relative growth rate of *A.rugosus* dropped to zero in the later harvest in waterlogged condition. The data was found significant for treatment at 1% level and for harvest at 5% level of probability (Table 7.4).

The net assimilation rate (Table 7.4) of *A.rugosus* was maximum in WAD and W4D regimes in comparison to waterlogged and W6D plants. The value decreased in 5th and 6th harvest. At the last harvest upswinging of NAR was marked. Maximum value of NAR was marked in W6D plant of *A.monilifer* at the 1st and 2nd harvest interval. In 2nd and 3rd harvest the same was the highest in W4D plant. Again during 3rd-4th, and 4th-5th harvest interval *A.monilifer* had maximum NAR in W6D plant. At the last harvest interval the value dropped to zero in *A.monilifer* in W6D plant. The

data was found significant for Tr. and Har. at 1% and 5% level of probability. Leaf area ratio in both the species decreased with the age of the plant. *A.monilifer* had maximum LAR in alternate day and 4th day watered plant than the waterlogged and 6th day watered plant right from 1st to the 6th harvest. During 7th and 8th harvest maximum LAR was observed in W6D plant. *A.rugosus* had different nature with respect to LAR. Maximum value of NAR in *A.rugosus* was found in WAD and W4D regimes during 1st and 2nd harvest. At the later harvest maximum LAR was observed in W6D plants in comparison to other regimes. Peak value of LWR was found in 2nd harvest in both the species. The value decreased gradually right from 2nd to the last harvest interval. More or less maximum value of leaf weight ratio was observed in WAD and W4D condition in comparison to waterlogged and W6D plants in both the species (Table 7.5).

Specific leaf area was found maximum in alternate day and 4th day watered plants in case of *A.monilifer* while the same for *A.rugosus* was maximum in waterlogged condition at 1st and 2nd harvest but at the 3rd and 4th harvest the SLA was maximum in W6D plant. Fluctuating value of SLA was noticed in both the species with respect to different ages of plant under different watering levels (Table 7.5).

The total chlorophyll in mg fresh weight tissue was higher in W4D and WAD of both the species right from 1st to the last harvest. The reduction of total chlorophyll was more in WL condition in comparison to W6D plant. Condition which corroborated with the data of chlorophyll a.b in the four regimes having higher value in W4D and WAD and declining on either extremes (waterlogged and drier soil) in *A.rugosus* and *A.monilifer* respectively (Table 7.8).

With regard to the reproductive behaviour waterlogged resulted in delayed flowering in both the species. However, flowering was observed earlier in drier condition. The number of flower and fruits were more in alternate day watered plant in all the species (Table 7.9).

DISCUSSION

The plant of *Alysicarpus* withstood a narrow range of soil moisture treatments. This explains its occurrence on a limited range of habitate in nature. The overall performance of both the species were best in pots watered on alternate days. Poorest growth of *A.monilifer* was in waterlogged condition and for *A.rugosus* in W6D condition. In waterlogged soil there is a lack of aeration which results in the poor growth of the plant. From a cursory perusal of the results it is evident that branching was more in alternate day and

4th day watered plants and that excessive as well as underwatering caused reduction in the number of branches. Specieswise differences was seen with *A.rugosus* a giving out branches a bit later and in lower number. More or less similar trend could be marked for the number of leaflets for both the species in alternate day watered plants. The differential behaviour of two species was marked in the sense that reduction in dry weight of *A.monilifer* was in waterlogged condition while more reduction of dry weight in W6D plant of *A.rugosus*. The greater biomass of both the species in alternate day watered condition is due to the better growth performance of plant. Such an observation have been reported by several other workers (Sktanhill, 1957; Pope and Magdwick, 1974; Etherington, 1984; Pandey and Goel, 1986). From a drastic reduction in *A.rugosus* under drier regimes (W6D), it might be inferred that it was poor performer in the dry and the desiccating conditions of the soil. It is worth noting that dry matter accumulation and the leaf area increase was maximum under alternate day watered plant, reducing on either side of the moisture variation from the field capacity being more intense in the waterlogged condition for *A.monilifer* and in the drier condition for *A.rugosus*. The results are in conformity with the observations of Walter (1955) and Coutts (1982). They have asserted that the sensitivity of plants to waterlogging varied with species, the stage of growth and the environmental condition prevailing thereon. From the data of RGR also the adaptability of *A.monilifer*

under water-stressed condition was indicated as it showed higher RGR in W6D condition, in all the harvest interval except during 2nd and 3rd harvest. At the 2nd and 3rd harvest both the species showed uniform RGR in the alternate day watered plant which reflected the indentical response of the two. Further reduced RGR and NAR of *A.rugosus* in water stressed condition are corroborated with the idea of Pope and Magwick (1974). Mutsaeirs (1983), that retarding effect of increasing water stress could be observed fully in the latter species. Bunce (1978) has also stated that leaf area expansion and NAR during soil water stress depend upon the degree and duration of stress. He observed the reduction of NAR and leaf area in soyabean and cotton due to soil water stress. Increased soil moisture tension decreased NAR (Denmead and Shaw, 1962). Lal (1978) has observed higher value of RGR and NAR in moderate watering and least in high water stress given to *Scoparia dulcis*. High moisture stress causes rapid respiration (Kramer and Kozlowski, 1960). This increased the dry weight of the plant and probably this is the reason of lesser value of NAR in 6th day watered plant in comparison to other treatments. But in waterlogged condition there is lack of aeration which reduced all the metabolic activities and affects the growth rate of the plant. Coming to the effect of aging, it is worth nothing that under stressed condition both the species displayed lower RGR at the later harvest interval- a phenomenon also observed by Evans (1972). From the higher value of

NAR of *A.monilifer* under the water stressed condition, its effect on the patterning of RGR was inferred. Further, in both the species the RGR appeared to be governed by the level of NAR.

The decrease in LAR of both the species with age, has been observed as an usual feature in grasses by Higgs and James (1969). The increase in LAR during early growth period and decrease later on is primarily caused by initial increase in the growth of leaves relative to stem and root and vice-versa (Friend *et al.*, 1965). The higher value of LAR and lesser values of NAR in the plant of *A.rugosus* under delayed watering in comparison to the plants growing under other sets of treatments indicate that the rate of accumulation of dry matter is comparatively slower, in spite of greater leaf area ratio. No definite relation could be drawn from the values of LWR with watering stresses. However, higher values of SLA and lower ones of LWR in these cases suggest more foliar expansion and less maturity (Blackman, 1968).

The specific leaf area indicated the differential response of the two species in varied soil moisture. The values of *A.monilifer* were higher in alternate day watered condition indicating freshness. On the other hand, its reduction in the W6D regime showed senscence (Evans and Hughes, 1962). Further from the higher value of *A.rugosus* in xeric condition the adatability of species to drought was inferred. More or less uniform shoot root ratio of *A.monilifer* under all the four

regimes a tendency of drought resistance for this species could be inferred. Keeping in view the observation of (Parson, 1969) that the stressed plants accumulated more in the root than in the shoot resulting in the lowering of S/R ratio as compared to those in well watered plants was marked in *A.rugosus*.

As regards chlorophyll content, both the species behaved indentically in having higher chlorophyll content in WAD and W4D regimes and that the plants under extremes of soil moisture namely waterlogged and dry condition displayed lower values. So was the case with chlorophyll a and b. In this context it may be noted that the results corroborate the findings of Tabbada and Flores (1983) and Sanches *et al.* (1983) with increased as well as decreased content respectively in the conditions of stress.

As regards the initiation of flowering it is clear that the waterlogged soil delayed the initiation of flowering. In this respect both the species behaved identically and this observation is in consonance with those of (Tabbada and Flores, 1983). Interestingly extreme condition did not allow normal seed setting of the fruit and reduced number of fruit per plant in WL and W6D plants. This finding is in contradiction of Monk *et al.* (1984) who observed that number of pods is directly proportional to high irrigation. In this context it is of interest that both the species did not differ at all.

CHAPTER - VIII

INTRASPECIFIC COMPETITION

INTRASPECIFIC COMPETITION

INTRODUCTION

The limited resources of the edaphoclimatic environment exert a competitive pressure on the individuals which results in the alteration of their physical architecture and growth behaviour. The magnitude of production depends upon the interaction among the individuals of a plant population and the proximity of the neighbours for resource utilization. The proximity of the neighbour has been reported to profoundly affect the plastic responses and the development of individual plant in a given habitat (Harper, 1977). Bradshaw (1965) has enumerated that leaf number, leaf shape, pattern of inflorescence and floral attributes as plastic characters and they constituted the morphological and physiological responses to the modification of the factors of their environment. Stebbins (1980) has reported the plasticity in dry matter production. Allocation of assimilates between different plant parts often become altered under the density stress. Clements (1907) on the basis of the experimental observations noted, "when the immediate supply of single necessary factor falls below the combind demand of the plants, competition begins. "Malthus (1978) visualised that population of organism is controlled by density dependent factors and mediated through over all performance which would have

significance for the survival values. Harper (1977) in a review has spelt out interference as the sum total of effect of the changes brought about under the influence of its neighbours. Interference leads to changes in the growth patterns which ultimately affect the productivity. Watkinson and Harper (1978) have reported a linear relationship between density and survivorship of individuals. Meaning thereby plants growing in poor ocndition usually show stunted growth on the other hand those growing in good condition although being densely populated show a higher survivorship. The differential behaviour comes largely owing to the varied adaptabilities of plants having direct bearing or their survival values. In this context it may be noted that such intraspecific competitions are related with the potential of the individual of the some species. The adaptation of the two types vary resulting into an interaction between the density effect and interference for harnessing the natural resources optimally. Black (1988) observed that larger plants maintained themselves while the stunted ones could not compete under the influence of the density stress. Williams (1960) observed marked differences in the reproductive growth attributes including number and weight of the fruit. Harper (1961) traced the responses of the plants of determinate and indeterminate system with former one responding to change in the number of component organs while the latter one by changes in the size of the organs as observed in

Vicia faba and *Helianthus annuus* respectively. Harper (1977) have reviewed the work on this aspect.

In the recent past the concept of growth analysis is being applied for working out the effect of parameters including RGR, NAR, LAR, SLA, LWR, S/R ratio etc. alongwith the other parameters like dry weight accumulation (Khan and Bradshow, 1976; Thompson and Beattle, 1981; Pristch and Rousel, 1983; Martin and Harding, 1982; Fower, 1984).

In view of the above introducting remarks it was considered worth while to work out the growth behaviour of the two species under different density stresses as under DI, DII. DIII and DIV representing one, two, three and four plants/pot respectively.

MATERIALS AND METHODS

Intraspecific Competition

In order to assess the impact of different intraspecific competition 4 sets of treatments were designed.

DI	One plant/pot
DII	Two plants/pot
DIII	Three plants/pot
DIV	Four plants/pot

The surface area of the pot was 176.6 cm^2. Results were assessed on per plant basis.

RESULTS

As can be seen in Table 8.1 the number of branch/plant was maximum in DI plant at every stages of growth and development. *A.monilifer* displayed more number of branches than *A.rugosus*. As regards the length of stem *A.monilifer* was longer in comparison to *A.rugosus* at every stages of growth and in different plant densities. Number of leaves per plant followed the trend of number of branches as *A.monilifer* bears more number of leaves than *A.rugosus* in DI, DII, DIII and DIV plants. But at the later stages of growth *A.rugosus* surpassed *A.monilifer*. The species showed same magnitude of reduction in DIV condition as compared to DI.

The dry matter accumulation (Table 8.2) did not show the effect of competition at early stages of growth. But the competition was well marked at later stages of growth. The magnitude of reduction in dry weight of plant was more in *A.monilifer* (662.70 mg) than in *A.rugosus* (475.75 mg) at 6th harvest interval. *A.monilifer* had on upper hand for more dry matter accumulation than *A.rugosus* in every treatment and at each harvest interval. Peak value of plant dry weight in *A.monilifer* was 1415.10

TABLE 8.1: Primary growth attributes of two species of *Alysicarpus* (*A. monilifer* and *A. rugosus*) at different ages during intraspecific competitions.

Attributes/ Treatment Species	Age of harvest (days)	Number of branches				Stem length (cm)				Number of leaves			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	28	1.0	1.0	1.0	1.0	2.6	2.2	3.4	3.0	4	4	6	5
A.rugosus		1.0	1.01	1.0	1.0	1.5	1.4	1.1	1.2	5	5	5	5
A.monilifer	35	2	3	3	3	3.4	3.5	3.6	5.0	11	11	8	8
A.rugosus		5	4	3	3	1.1	1.4	1.0	1.3	8	7	7	6
A.monilifer	42	4	4	4	5	4.7	3.7	5.5	3.0	17	12	13	9
A.rugosus		5	4	4	4	1.5	1.8	1.1	1.4	10	11	10	9
A.monilifer	49	5	4	4	5	8.1	6.3	5.5	7.8	24	9	15	16
A.rugosus		5	4	4	5	2.0	2.1	1.8	2.4	24	22	17	20
A.monilifer	56	6	5	5	5	9.7	11.8	8.6	8.9	51	48	29	29
A.rugosus		6	5	5	4	4.0	3.2	2.7	2.4	45	32	27	18
A.monilifer	63	9	9	8	7	23.1	19.1	18.9	15.7	92	77	69	37
A.rugosus		9	7	7	7	10.2	6.8	7.8	8.7	85	76	82	3
A.monilifer	70	11	11	11	9	30.4	26.5	25.8	21.8	166	84	82	64
A.rugosus		13	12	8	9	15.2	18.1	11.8	14.7	120	117	71	101
A.monilifer	77	14	17	13	12	37.4	30.1	30.1	32.3	181	141	121	74
A.rugosus		13	12	9	11	26.4	21.7	14.2	19.8	229	132	60	49

DI = One plant/pot; DII = Two plants/pot ; DIII = Three plants/pot; DIV = Four plants/pot.

TABLE 8.2: Growth parameters of two species of *Alysicarpus* (*A.monilifer* and *A.rugosus*) at different ages during intraspecific competitions.

Attributes/ Treatment Species	Age of harvest (days)	Dry weight/plant (mg)				Leaf area (cm^2)			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	28	12.50 ±1.80	6.40 ±0.04	10.30/ ±0.28	13.03 ±0.39	2.14	2.22	3.18	3.34
A.rugosus		6.30 ±0.98	5.10 ±0.63	3.80 ±0.44	8.20 ±0.19	2.28	2.28	2.24	2.68
A.monilifer	35	16.00 ±0.38	32.15 ±0.68	23.70 ±1.82	19.20 ±1.01	5.19	7.99	7.01	3.72
A.rugosus		18.01 ±1.88	9.60 ±0.43	8.70 ±0.19	21.01 ±3.12	3.01	4.99	2.84	5.68
A.monilifer	42	42.50 ±5.10	36.70 ±7.20	44.80 ±2.22	28.70 ±0.13	7.16	7.65	11.32	10.86
A.rugosus		14.09 ±4.22	15.02 ±3.88	15.30 ±0.88	24.60 ±4.33	4.99	7.03	5.82	6.91
A.monilifer	49	128.08 ±4.35	68.10 ±8.22	62.10 ±3.22	137.60 ±9.68	18.18	8.08	13.65	13.67
A.rugosus		110.30 ±4.32	28.99 ±1.12	60.42 ±6.65	98.70 ±10.82	9.36	11.93	8.29	11.43

Contd.

TABLE 8.2: Contd.

Attributes/ Treatment Species	Age of harvest (days)	Dry weight/plant (mg)				Leaf area (cm^2)			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	56	226.80 ±8.88	275.60 ±6.99	294.89 ±8.42	200.03 ±9.23	40.35	32.02	15.47	15.63
A.rugosus		188.20 ±15.44	162.60 26.08	210.60 ±36.35	115.10 ±24.98	28.10	15.75	15.12	15.93
A.monilifer	63	662.70 ±55.65	562.50 ±42.52	548.30 ±43.55	246.65 ±25.26	125.91	45.78	39.45	36.44
A.rugosus		475.75 ±45.62	375.65 ±36.54	362.20 ±45.91	185.90 ±3.22	64.89	35.92	35.20	19.53
A.monilifer	70	1212.52 ±50.96	1008.59 ±105.42	685.40 ±7.32	605.20 ±65.52	49.16	50.85	39.65	57.12
A.rugosus		654.55 ±48.56	608.10 ±49.12	425.00 ±63.49	506.62 ±32.65	40.64	43.60	48.46	91.72
A.monilifer	77	1415.10 ±40.32	1950.60 ±95.32	1332.80 ±65.64	685./10 ±40.72	106.38	113.75	52.88	60.72
A.rugosus		1380.40 ±56.65	1360.20 ±65.68	632.20 ±32.32	665.50 ±33.64	124.15	56.98	26.75	69.65

mg against 1380.40 mg of *A.rugosus*. The data were found significant for Sp. and harvest. Leaf area expansion followed the trend of dry matter accumultion. More area in DI plant and least area in DIV plant. Reduction of area in DIV condition were 30% and 31% for *A.monilifer* and *A.rugosus* respectively. Maximum leaf area was found in *A.monilifer* in comparison to *A.rugosus*. The data were found highly significant for harvest and significant for species and treatment at 0.1% and 1% level while interaction i.e. Har. x Treat. was also significant at 1% level of probability.

Relative growth rate varied from 1.06 to 0.20 for *A.monilifer* while the same varied from 1.22 to 0.48 for *A.rugosus* Fluctuating values were obtained for both the species with respect to different stages of growth and development. The former species had more value in DII and DIII and less in DI and DIV than the latter during the 1st and 2nd harvest interval. At the later harvest intervals (2-9) *A.monilifer* had an upperhand in DIII and DIV condition in comparison to *A.rugosus* which shows more value in DI and DII condition. During the harvest interval 3rd and 4th more value of *A.rugosus* were found in DI, DII and DIII plant except in DIV plant where *A.monilifer* is higher than the *A.rugosus*. At the last harvest interval (5-6) also *A.rugosus* shows higher value than *A.monilifer* in DI, DII and DIII plants but in DIII plant *A.monilifer* had upper value than *A.rugosus*. The data were found significant for harvest

TABLE 8.3: Derived growth parameters of the two species of *Alysicarpus* (*A.monilifer* and *A.rugosus*) at different ages during intraspecific competition.

Attributes/ Treatment Species	Age of harvest (days)	R G R				N A R			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	1-2	0.22	1.48	0.77	0.35	0.97	5.45	2.81	1.70
A.rugosus		0.94	0.54	0.68	0.85	4.34	1.24	1.66	9.57
A.monilifer	2-3	0.93	0.12	0.61	0.37	3.80	0.47	2.27	1.31
A.rugosus		1.23	0.39	0.50	0.15	11.03	0.80	1.70	2.21
A.monilifer	3-4	1.08	0.60	0.29	1.53	6.23	3.35	1.18	8.28
A.rugosus		1.99	0.91	1.32	1.34	5.96	1.61	5.82	22.24
A.monilifer	4-6	0.55	1.38	1.55	0.37	3.36	11.20	15.00	4.07
A.rugosus		0.21	1.60	1.23	0.15	1.43	9.09	11.90	9.17
A.monilifer	5-6	1.06	0.70	0.61	0.20	5.76	7.40	9.38	1.80
A.rugosus		1.22	0.83	0.52	0.48	7.52	8.46	6.08	0.48
A.monilifer	6-7	0.59	0.57	0.22	0.88	4.45	8.37	0.01	7.61
A.rugosus		0.30	0.47	0.16	0.97	2.62	5.55	1.48	26.13
A.monilifer	7-8	0.15	0.65	0.64	0.11	1.75	11.92	14.04	1.31
A.rugosus		0.67	0.80	0.38	0.28	5.79	15.17	5.76	7.13

TABLE 8.4: Derived growth parameters of the two species of *Alysicarpus* (*A.monilifer* and *A.rugosus*) at different ages during intraspecific competition.

Attributes/ Treatment Species	Age of (days)	L A R				S L R			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	28	0.17	0.29	0.27	0.23	0.62	0.55	0.47	0.44
A.rugosus		0.30	0.36	0.45	0.28	0.61	0.71	0.82	0.54
A.monilifer	35	0.29	0.25	0.27	0.18	0.58	0.47	0.51	0.36
A.rugosus		0.15	0.48	0.30	0.25	0.59	0.88	0.52	0.45
A.monilifer	42	0.20	0.22	0.26	0.38	0.43	0.46	0.60	0.91
A.rugosus		0.07	0.50	0.34	0.26	3.27	0.74	0.62	0.54
A.monilifer	49	0.15	0.13	0.22	0.10	0.32	0.26	0.45	0.24
A.rugosus		0.08	0.37	0.15	0.11	0.21	0.77	0.30	0.21
A.monilifer	56	0.17	0.11	0.05	0.07	0.36	0.29	0.13	0.22
A.rugosus		0.20	0.09	0.07	0.13	0.30	0.27	0.20	0.32
A.monilifer	63	0.18	0.07	0.06	0.14	0.43	0.18	0.18	0.38
A.rugosus		0.13	0.08	0.08	0.10	0.27	0.18	0.19	0.23
A.monilifer	70	0.08	0.04	0.05	0.08	0.32	0.16	0.16	0.29
A.rugosus		0.15	0.07	0.11	0.17	0.06	0.17	0.32	0.47
A.monilifer	77	0.07	0.05	0.03	0.08	0.33	0.19	0.14	0.38
A.rugosus		0.08	0.03	0.03	0.09	0.38	0.18	0.14	0.42

TABLE 8.4: Contd.

Attributes/ Treatment Species	Age of (days)	L A R				S/R Ratio			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	28	0.27	0.53	0.57	0.51	0.63	3.50	5.20	4.22
A.rugosus		0.50	0.51	0.55	0.52	2.58	2.74	3.98	3.73
A.monilifer	35	0.51	0.52	0.53	0.50	3.36	3.392	5.08	5.88
A.rugosus		0.26	0.54	0.56	0.55	1.76	3.85	3.19	4.32
A.monilifer	42	0.46	0.48	0.44	0.42	0.18	1.15	3.48	3.90
A.rugosus		0.02	0.67	0.55	0.48	0.93	3.04	3.81	4.78
A.monilifer	49	0.45	0.47	0.50	0.41	0.23	3.08	3.72	3.67
A.rugosus		0.42	0.48	0.51	0.57	3.02	3.44	3.59	3.95
A.monilifer	56	0.47	0.39	0.39	0.35	0.20	2.74	3.16	3.18
A.rugosus		0.68	0.35	0.35	1.06	0.81	2.31	2.07	2.20
A.monilifer	63	0.42	0.43	0.43	0.37	1.28	3.38	4.14	5.06
A.rugosus		0.48	0.47	0.48	0.43	2.24	3.68	3.97	3.48
A.monilifer	70	0.28	0.28	0.34	0.31	5.53	3.73	6.22	12.74
A.rugosus		0.53	0.38	0.34	0.37	3.32	4.11	4.30	4.16
A.monilifer	77	0.21	0.27	0.26	0.22	5.41	3.24	5.47	13.03
A.rugosus		0.24	0.21	0.27	0.23	0.62	5.95	6.63	7.48

and for interaction Tr. x Har. and Har. x Sp. at 5% level of probability (Table 8.3).

Net Assimilation rate (Table 8.3) fluctuated in the four treatments right from the 1st to 5th harvest intervals. It also decreased in the subsequent harvests. A fainty tendency of a lower rate was observed for *A.monilifer* in DII condition. Data were significant for harvest leaf area (SLA Fig.8.1) in both the species reduced from the 1st harvest onward. The values were more in DI and DIV and DIII in *A.rugosus* while *A.monilifer* showed somewhat higher value in DI.

The leaf weight ratio (LAR) did not show significant trend with respect to different treatments. Although there was decreasing tendency from 1st harvest to onward. Shoot-root ratio was higher in the plant of both the species. The ratio was higher in DIII and DIV plants of *A.monilifer* than that of *A.rugosus* (Fig. 8.2).

Chlorophyll Content

The content of chlorophyll 'a' varied from 0.60 to 0.73 and from 0.74 to 0.78 mg of fresh weight tissue of *A.monilifer* and A.rugosus respectively. The respective values for chlorophyll 'b' were 1.14 to 0.93 and from 1.26 to 1.1 mg of fresh weight tissue of *A.monilifer* and *A.rugosus* respectively. The total chlorophyll content was from 1.87 to 1.49 and from 2.04 to 1.72 mg fresh

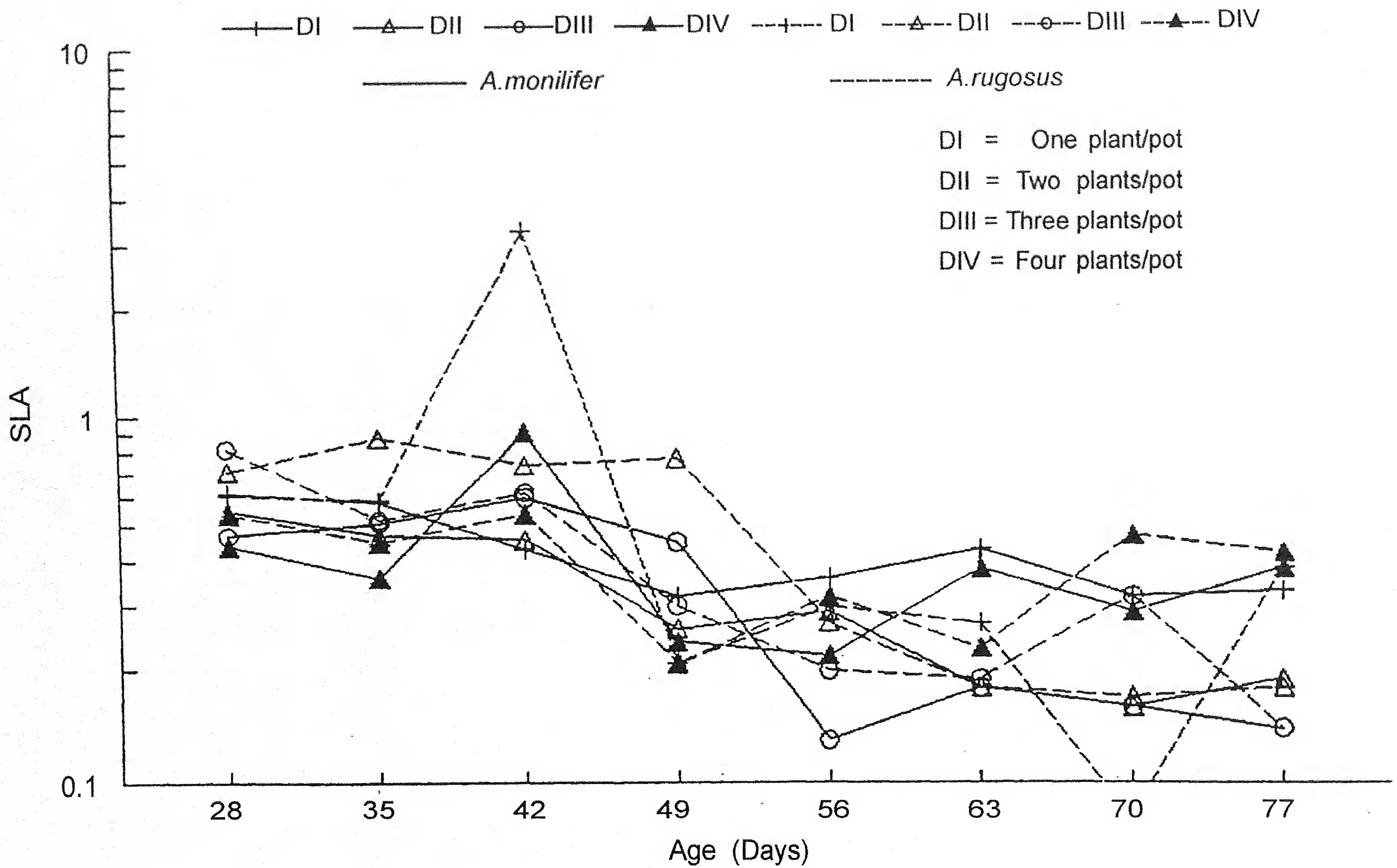

Fig.8.1: Derived growth parameters of two species of *Alysicarpus* (*A.monilifer* & *A.rugosus*) at different ages during intraspecific competition

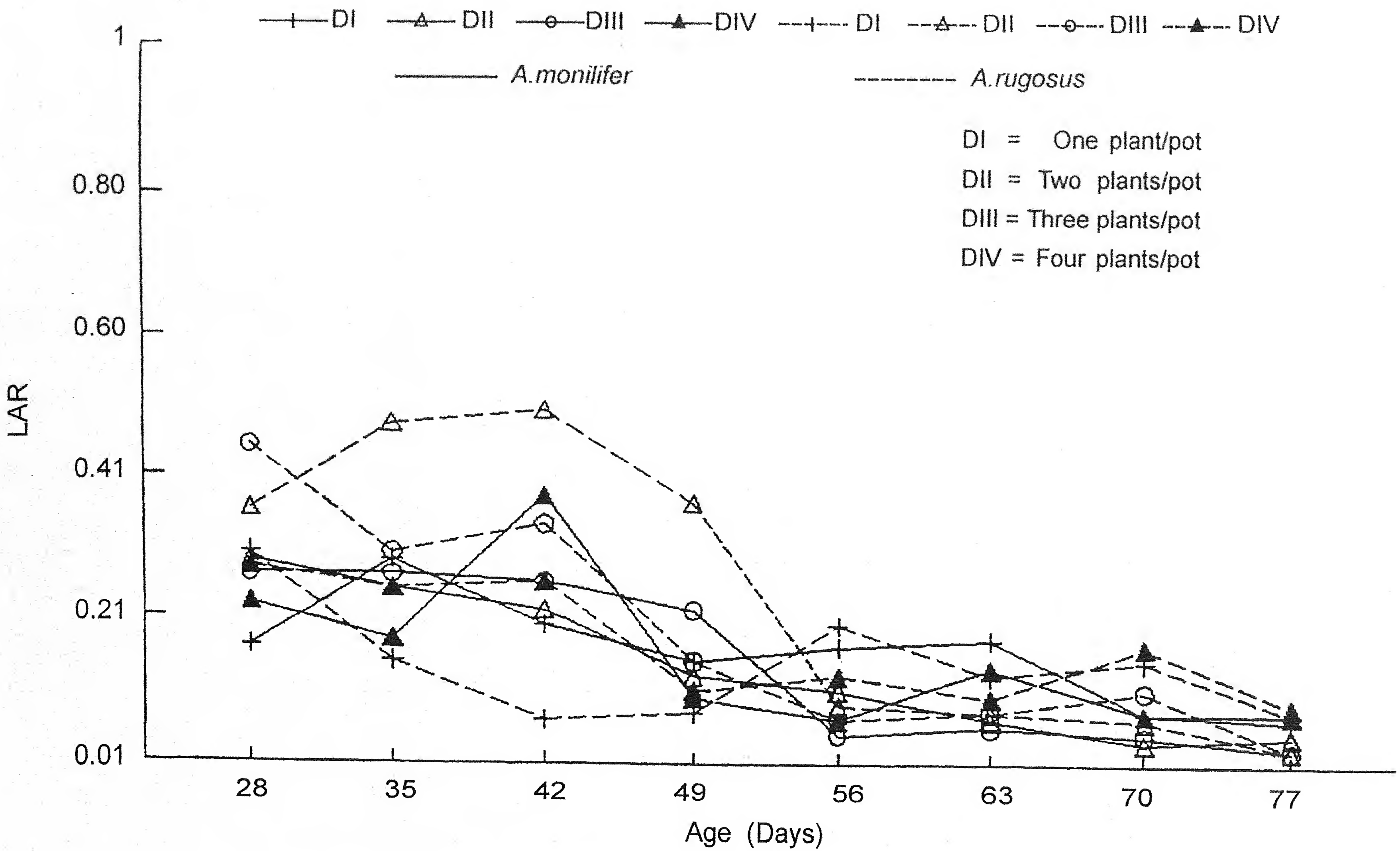

Fig.8.2: Derived growth parameters of two species of *Alysicarpus* (*A.monilifer* & *A.rugosus*) at different ages during intra specific competition

TABLE 8.5: Analysis of variance for the data on dry matter accumulation, leaf area and the LAR.

Source of variation	Degree of freedom	Dry matter accumulation		Leaf area		L A R	
		MS	F	MS	F	MS	F
Species	1	31601.70	6.69*	525.68	9.09**	0.0251	7.66
Treatment	3	8442.62	1.78	500.21	8.66**	0.0005	6.70
Harvest	5	215506.02	45.70***	2634.66	45.61***	0.0632	19.16***
Tr. x SPP.	3	556.57	8.45	82.81	1.42	0.0280	8.46**
Tr. x Har.	15	8514.60	1.80	303.85	5.26**	0.0107	3.24*
Har. x SPP.	5	7424.31	1.56	140.73	2.42	0.0013	2.17
Residual	15	4713.89		56.74		0.0033	

*** = Significant at 0.1% level; ** = Significant at 1% level; * = Significant at 5% level.

TABLE 8.6: Analysis of variance for the data on RGR and NAR.

Source of variation	df	R G R		N A R	
		MS	F	MS	F
sp.	1	0.1103	1.05	15.0797	1.06
Tr.	3	0.2340	2.01	2.4960	3.60
Har.	4	0.3365	3.15*	41.7492	4.62*
Tr. x SPP.	3	0.0735	1.57	20.3164	2.24
Tr. x Har.	12	0.4036	3.47*	38.9527	4.31**
Har. x SPP.	4	0.1031	8.61*	7.2365	1.23
Residual	12	0.1160		9.0108	

* = Significant at 5% level; ** = Significant at 1% level.

TABLE 8.7: Effect of intraspecific density stress on chlorophyll content in varying sowing date.

Attributes/ Treatment Species	Age of harvest (Days)	mg Chlorophyll a/g fresh weight tissue				mg Chlorophyll b/g fresh weight tissue				mg total Chlorophyll/g fresh weight tissue			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	35	0.51	0.55	0.58	0.52	0.53	0.95	0.30	0.85	1.04	1.50	1.38	1.37
A.rugosus		0.58	0.67	0.63	0.58	0.90	1.01	0.91	0.98	1.48	1.68	1.54	1.56
A.monilifer	42	0.48	0.67	0.63	0.58	0.81	1.12	1.07	0.91	1.29	1.79	1.70	1.49
A.rugosus		0.66	0.68	0.68	0.64	1.01	1.14	1.12	1.08	1.67	1.82	1.80	1.72
A.monilifer	49	0.52	0.76	0.65	0.67	0.85	1.26	1.11	1.14	1.37	2.02	1.76	1.81
A.rugosus		0.73	0.77	0.70	0.68	1.03	1.30	1.15	1.16	1.76	2.07	1.85	1.84
A.monilifer	56	0.65	0.59	0.60	0.66	1.02	0.86	0.88	1.04	1.67	1.45	1.48	1.70
A.rugosus		0.71	0.68	0.75	0.75	1.13	1.00	1.16	1.18	1.84	1.68	1.91	1.93
A.monilifer	63	0.73	0.58	0.62	0.60	1.14	0.91	0.94	0.93	1.87	1.49	1.56	1.53
A.rugosus		0.78	0.32	0.73	0.74	1.26	1.04	1.23	1.10	2.04	1.76	1.96	1.84

DI = One plant/pot; DII = Two plants/pot; DIII = Three plants/pot; DIV = Four plants/pot.

TABLE 8.8: Reproductive growth attribute of two species of *Alysicarpus* (*A.monilifer* and *A.rugosus*) at different intraspecific competitions.

Attributes/ Treatment Species	Age (Days)	Days of flowering primordia after seed sowing				Number of inflorescence/plant				Number of flower/plant			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	28	-	-	-	-	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-	-	-	-	-
A.monilifer	35	-	-	-	-	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-	-	-	-	-
A.monilifer	42	-	-	-	-	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-	-	-	-	-
A.monilifer	49	-	-	-	-	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-	-	-	-	-
A.monilifer	56	-	-	-	-	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-	-	-	-	-
A.monilifer	63	64	69	67	63	15.2	14.2	10.2	7.0	-	-	-	-
A.rugosus		62	69	64	71	21	9.6	11.0	-	-	-	-	-
A.monilifer	70	-	-	-	-	28	22.5	14.5	10.0	575.5	420.5	295.5	120.0
A.rugosus		-	-	-	-	32.5	24.5	20.5	22.6	1220.5	245.0	230.3	210.5
A.monilifer	77	-	-	-	-	32.0	35.0	25.3	18.0	595.0	990.0	820.0	475.0
A.rugosus		-	-	-	-	75.0	45.0	30.0	25.0	1765.0	865.0	385.0	510.0

TABLE 8.8: Contd.

Attributes/ Treatment Species	Age (days)	Number of fruit/plant				Dry weight of fruit plant(mg)			
		DI	DII	DIII	DIV	DI	DII	DIII	DIV
A.monilifer	28	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	35	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	42	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	49	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	56	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	63	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	70	-	-	-	-	-	-	-	-
A.rugosus		-	-	-	-	-	-	-	-
A.monilifer	77	155	135	120	110	255	200.5	175.5	165.5
A.rugosus		370	275	200	165	180.3	200.1	140.5	130.6

weight tissue in the two species respectively. Time taken for flowering varies from 70 days to 65 days in *A.monilifer* and 72 to 63 days for *A.rugosus* in the four treatments. The number of inflorescene/plant was maximum in DI and minimum in DIV in both the species. *A.rugosus* had higher number of inflorescene in comparison to *A.monilifer* in every treatment. Number of flowering plant was also maximum in DI and minimum in DIV. More flowers were observed in *A.rugosus* in DI and DIV plant while in *A.monilifer* it was higher in DII. DIII condition. Number of fruit plant was also maximum in DI and minimum in DIV. *A.rugosus* had more number of fruit than *A.monilifer*. Dry weight of fruit/plant varied from 255.0 mg in DI to 165.5 mg in DIV in *A.monilifer* while for other species it varied from 180.3 mg in DI to 130.6 mg in DIV. *A.monilifer* had an upperhand to this content.

DISCUSSION

From higher number of branches in DI (one plant/pot) it is evident that sparser stands resulted into more banching and that the denser the population lesser the number of branches for the species. This had been a usual phenomeon in case of annuals. The reduction of branches in the denser stands has also been reported by Seschenss and Legere (1982). The response of two species are

idential with regard to different treatment and competition stress. More leaves in DI in comparison to DIV shows overcrowding of leaves in denser condition.

Dry matter acquisition in the earlier stage of development did not face competition effect due to proper spacing and unexhausted nutrient in the soil while at later harvest when the plant attains maturity and had extreme requisition from soil. The adaptabilities of *A.rugosus* over the other species was evident in the lesser magnitude of reduction particularly in the later stages of growth. On the other hand *A.monilifer* in DIV regime displayed greater imbalance under the density stress as evidenced in the much reduced biomass. These findings are fully in consonance with those of Bazar and Harper (1976); Tripathi and Gupta (1980); Fowler (1984); Warick *et al.* (1987) and Renata (1987). The increase in the leaf area corresponded to dry weights. However, adaptability of *A.monilifer* was evident with lesser reduction (80%) under denser stands. Thus, the reduction of leaf area with density in in line with the observations of Deschenese and Lagere (1982). The data on RGR indicated less significant effect of density stress on this attributes. It is interesting to note that except for slightly higher rate for plants under DI on such variation was observable in denser stand. Generally the reduction of RGR under denser stand is a common feature (Fowler, 1984). However, in the present case in all

probability, the noncrowding of leaves would have been the cause of less variable relative growth rate.

From the fluctuating values of NAR under the different stands no definite trend could be seen in the two although in the denser stand, a reduction indicated a retarding effect in both the species. Since the rates declined to a minimum at different ontogenetic stages. In the two differential adaptabilities of the two species could be inferrred. In this context it is also worthnoting that *A.monilifer* had lesser NAR a bit later indicating thereby robustness and longer life span (Evans, 1972). Koller *et al.* (1970) have reported an upswinging of NAR in many crop plants and annuals. This upswinging was noticeable in the two species under the density stress. These results also lie in contravention of Clark and Simpson (1978) who have observed the decreased RGR and NAR with increasing population stand.

From the lower LAR of both the species in DI, and increasing trend of this attribute with density was inferred. Reports are there with increasing LAR under the influence of density stress (Escasines, 1981). On the other had Clarke and Simpson (1978) had found decreasing trend with density. The lowering of the values in the two species was indicative of their being short lived annuals. The specific leaf area ratio and leaf weight ratio did not indicate any

specific pattern for either species. From a higher shoot-root ratio under the denser stand in both the species the indentical responses of the two was indicated. Oladokum (1978) has observed higher shoot-root ratio in the denser stand for deriving nutrients more competitively than in the sparser ones. This might be also the case here in the two species for an enhanced shoot-root ratio in DIV plants. From the data on chlorophyll a, b and total chlorophyll no significant variation could be discernible in either species under different stands.

The initiation of flowering appeared delayed in the denser stands probably because of disturbed morphogenetic set up in both the species. As regards the fruit and flower both the species behaved indentically in having maximum number under DI stand and minimum in DIV plants, indications resemblance with the finding of other workers including Escasinas *et al.* (1981) that they decreased with density.

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CHAPTER - IX

SUMMARY

SUMMARY

The present study is concerned with the ecological studies of two herbaceous species around Orai (Jalaun) 25^{0} 59' North latitude and 79^{0} 37' East longitude. Two herbaceous species i.e. *Alysicarpus monilifer* and *Alysicarpus rugosus* were selected for detail investigation. The thesis contains the result of studies made on seed characteristics and germination, standing crop biomass, primary productivity and energy dynamics, effect of shading and soil moisture on growth, and intraspecific competition. A consideration to the economic aspect has also been given in the present study. The field observations and samplings were carried out at one week (7 days) intervals.

Alysicarpus monilifer DC and *Alysicarpus rugosus* DC. family Leguminosae, is an annual legume. It is a common legume of important grass field in India. The plant has much economic value. The species has great ecological amplitude and is widely distributed in tropical as well as in temperate region.

The seed germination was performed in petridishes at different temperatures. The effect of storage condition, light, salt stress and growth substances on germination was observed at the optimal

temperature (i.e.20^0C). The development and breakage of dormancy were also studied. The growth of plants was studied on culturing them in pots under the varying conditions of sowing dates, light intensity, soil moisture and intraspecific competition. Plant samples were harvested at weekly intervals and dry matter accumulation, leaf area expansion, RGR, NAR, LAR, LWR, SLA and S/R ratio were estimated. Chlorophyll content, data on the time taken for floral initiation and number of pods and seeds/plant were also investigated in some of the cases. In the early stage of seed development there was very less extent of seed coat dormancy. Gradually, with maturity of the seed, the seed coat dormancy increased approaching the maximum in dry seed. This was found to be directly affected on storage of the seed at low temperature (10^0C). In this respect *A.monilifer* was more affected than *A.rugosus*. The viability of the seed was maintained at 0^0C. The high (30^0C and low 10^0C) constant temperatures also helped to break the seed coat dormancy for both the species was 20 ± 2^0C and 40 ± 5^0C as minimal and maximal respectively. Blue light was found more effective for the germination and early growth development of *A.rugosus*. The water stress (mannitol) was not beneficial for *A.monilifer*. However, the percentage of germination lowered to 45% in *A.rugosus* under 0.5 M concentration in

comparison to the control. The stress caused by NaCl resulted into more severe effect with increasing concentration to 0.25 M and onwards and complete inhibition of germination in both the species. Na_2SO_4 also had adverse effect on germination as well as seedling growth. The effect appeared to be more pronounced in *A.rugosus* and logically *A.monilifer* showed more tolerance to such stresses. IAA and GA have not significant effect on germination. On the other hand the growth of radicle was inhibited by MH. Thiourea resulted in breakage of dormancy was evidenced in both the species. Hardest seed coat was evidenced in both the species but hardest seed coat was observed in *A.monilifer* in comparison to *A.rugosus* .

The standing crop biomass in different plant compartments was found to be variable with the age of plant. The total plant biomass of aging plant indicated a sigmoid curve in two species of *Alysicarpus*. Highest percent contribution of plant parts to total plant biomass of *Alysicarpus monilifer* and *Alysicarpus rugosus* was of leaf component. Of the plant primary productivity all values were positive except root of the two species. Mean calorific value in both the species were variable in the different plant parts of species. *A.monilifer* should comparatively higher energy content in comparison to *Alysicarpus rugosus*. As regards the shading affect *A.monilifer* appeared more tolerant than *A.rugosus*. The reduction

of light upto 30 % caused lowering of dry matter accumulation ,leaf area expansion and RGR. However, the reduction of light upto 10% caused enhancement of LAR with lowering of light was evidenced in both the species right from 1st to the last harvest. The decrease of LAR with light could be attributed to LWR and SLA although in both the species the LWR was more responsible in determining the level of LAR. The chlorophyll content increased with shading in the two species and this caused delay initiation of flowering as well as reduced number of flower and fruit.

The effect of varying soil moisture indicated a better performance of *A.monilifer* and *A.rugosus* in alternate day watered plants. The soil moisture around the field capacity provided a better performance. The two species withstood a narrow range of soil moisture treatments. The poorest growth of *A.monilifer* was observed in water logged condition while that of *A.rugosus* in W6D condition. Dry matter accumulation and leaf area expansion of both the species was maximum under alternate day water plant. From the higher value of RGR of *A.monilifer* under stressed condition (W6D), its adaptability in deficit water was indicated. In the interval between the 2nd and 3rd harvest both the species showed uniform RGR in a condition of alternate day watering reflecting their identical response. Reduced RGR and NAR of *A.rugosus* in water

stressed condition was noted. Coming to the effect of aging, it is worthnoting that under stressed condition both the species displayed lower RGR at the later harvest interval. The decrease in LAR of both the species corresponding with age has been observed as an usual feature. More or less uniform shoot root ratio under all the four harvests indicated an identical tendency of drought resistance in them. Both the species behaved identically in having higher chlorophyll content in WAD and W4D regimes and lower chlorophyll content under waterlogging condition. The later condition also delayed the initiation of flowering. Early flowering and fruiting were observed in the species grown in desiccation. Maximum flower and fruit were noted in alternate day watered plants.

The intraspecific competition indicated identical response of both the species showing maximum accumulation of dry matter in DI plant (one plant/pot). However, the magnitude of decrease was more in case of *A.monilifer* was evident in having a lesser reduction of leaf area was in tune with that of the dry weight. The adaptability of *A.monilifer* was evident in having a lesser reduction of leaf area in the stands of four plants/pot. From the higher value of RGR in DI, better performance of sparser stands was evident. In this context, plants of *A.rugosus* appeared to be better performer even in denser stands as a lesser fluctuation of RGR was witnessed. From

the decreasing tendency of LAR with aging under all the stands, annual nature of the plant was marked. From the higher shoot-root ratio under the denser stands in both the species the identical response of the two species was indicated. Interestingly the chlorophyll content seemed to be the same in all the stands of the two species. The initiation of flowering was delayed in the denser stands while the yield of flower and fruits were more in sparser one.

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